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Fiscal Year 2003 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

United States
Department of Energy
P.O. Box 550
Richland, Washington 99352

Project Hanford Management Contractor for the
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DOE/RL-2003-58
Revision 0

Fiscal Year 2003 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations

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April 2004

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Assistant Secretary for Environmental Management

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APPENDICES (on CD in hard copies)

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TERMS

bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
DNAPL	dense nonaqueous phase liquid
DQO	data quality objectives
DOE	U.S. Department of Energy
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
FH	Fluor Hanford, Inc.
FY	fiscal year
GAC	granular activated carbon
gpm	gallons per minute
LERF	Liquid Effluent Retention Facility
MCL	maximum contaminant level
MTCA	*Model Toxics Control Act*
N/A	not applicable
OU	operable unit
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratory
ppmv	parts per million by volume
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation Facility
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
RPD	relative percent difference
TCE	trichloroethene
WAC	*Washington Administrative Code*
WIDS	Waste Information Data System

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	millibecquerel	millibecquerels	0.027	picocuries

1.0 INTRODUCTION

Five pump-and-treat systems are being operated by Fluor Hanford, Inc. (FH) at the Hanford Site under interim Records of Decision (RODs). Two of the systems, the subject of this fiscal year 2003 (FY03) annual report, are located in the 200 West Area (Figure 1-1). The 200-UP-1 Groundwater Operable Unit (OU) pump-and-treat system is removing primary contaminants uranium and technetium-99, and secondary contaminants carbon tetrachloride and nitrate. The 200-ZP-1 Groundwater OU pump-and-treat system removes primarily carbon tetrachloride and secondary contaminants chloroform and trichloroethene (TCE). Three other systems are operating at sites along the Columbia River. The 100-HR-3 OU is removing hexavalent chromium from groundwater at the 100-D and 100-H sites. Similarly, the 100-KR-4 OU is removing hexavalent chromium at the 100-K Area, and the 100-NR-2 OU is removing strontium-90 from groundwater at the 100-N Area.

Interim RODs were issued for the 200-UP-1 OU in 1997 (*Record of Decision for the 200-UP-1 Interim Remedial Measure* [EPA et al. 1997]) and the 200-ZP-1 OU in 1995 (*Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* [EPA et al. 1995]). Each interim ROD specified action levels of contaminants and identified the plume concentrations and locations to be targeted by the pump-and-treat systems. Remedial action objectives (RAOs) were identified for the 200-UP-1 OU and included the following:

- Reducing contamination in the area of highest concentrations of uranium and technetium-99 to below 10 times the cleanup level under the *Model Toxics Control Act* (MTCA) (*Washington Administrative Code* [WAC] 173-340), and 10 times the maximum contaminant level (MCL) for technetium-99.
- Reducing potential adverse human health risks through reduction of contaminant mass.
- Preventing further movement of these contaminants from the highest concentration area.
- Providing information that will lead to development and implementation of a final remedy that will be protective of human health and the environment.

The specific remedy section of the 200-UP-1 interim ROD identifies the area of highest concentration of uranium and technetium as corresponding to the area where concentrations are within the 480 µg/L and 9,000 pCi/L plume contours, respectively.

The RAOs for the 200-ZP-1 OU include the following:

- Reducing contamination in the area of highest concentrations of carbon tetrachloride.
- Preventing further movement of these contaminants from the highest concentration area.
- Providing information that will lead to development of a final remedy that will be protective of human health and the environment.

The specific remedy section of the 200-ZP-1 interim ROD identifies the area of highest concentration as corresponding to the area within the 2,000 to 3,000 µg/L contour of carbon tetrachloride. The drinking water standard (DWS) for carbon tetrachloride is 5 µg/L.

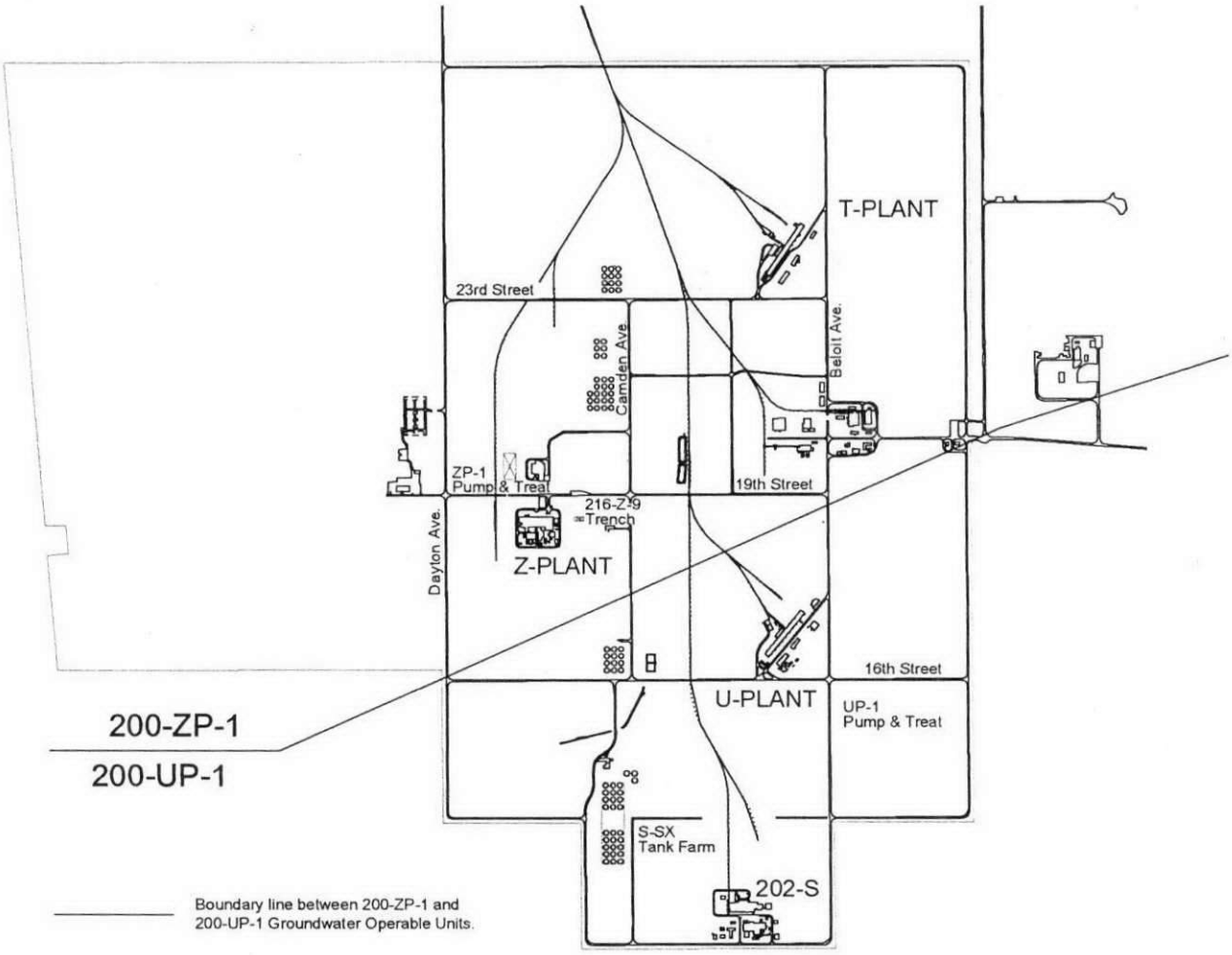
Extraction rates required for success were also identified for each primary contaminant at the two OUs and are discussed in the respective OU sections of this report.

A 5-year review, required by the U.S. Environmental Protection Agency (EPA) to assess remediation effectiveness, was first conducted in 2000 for all active pump-and-treat systems and was documented in *USDOE Hanford Site First Five-Year Review Report* (EPA 2001). Virtually all of the actions identified in this 5-year review were closed out in FY02 (*Fiscal Year 2002 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations* [DOE-RL 2003a]). One remaining action, to develop a geochemical model for uranium at the 200-UP-1 OU, is to be completed in FY04. A second 5-year review is scheduled to begin in FY05.

The format of this report is similar to previous years' reports, but much of the supporting data has been moved to appendices included on a compact disc at the back of the document. The report contains two sections (one for 200-UP-1 [Section 2.0] and one for 200-ZP-1 [Section 3.0]) that address each of the pump-and-treat systems, as well as a concluding discussion on respective treatment system costs (Section 4.0). For each OU section, subsections will discuss the following information:

- Description of modifications and changes to the pump-and-treat systems, new wells drilled, and other changes to the OU during FY03
- Summary of extraction well data
- Discussion of treatment system performance
- Discussion of contaminant trends at extraction and key monitoring wells
- Examination of groundwater and plume responses to both regional geohydrologic changes and groundwater extraction
- Presentation of a conceptual model update outlining the current understanding of interactions between site geology, hydrogeology, and waste site operations to define the fate and transport of target contaminants in the area of the pump-and-treat system
- Discussion of quality assurance and quality control sampling results.
- Conclusions and recommendations on pump-and-treat system effectiveness and plume monitoring system effectiveness.

Figure 1-1. Hanford Site 200 West Area.



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2.0 200-UP-1 OPERABLE UNIT PUMP-AND-TREAT SYSTEM

Measurable progress was made toward meeting the four RAOs for the 200-UP-1 OU pump-and-treat system in FY03. As required, further movement of contaminants from the high-concentration portion of the plume was prevented, health risks were reduced through reduction of contaminant mass, and information was collected that will support development of a final remedy. Based on the most recent well data for FY03, technetium-99 concentrations were below the RAO of 9,000 pCi/L and, at many wells, were approaching or below the DWS of 900 pCi/L. For uranium, all monitoring and extraction wells dropped below the RAO of 480 µg/L, with the exception of well 299-W19-43, which was exactly at that value during the July 2003 sampling event.

During FY03, the pumping system was comprised of three extraction wells: 299-W19-36, 299-W19-39, and 299-W19-43. Five monitoring wells were used to determine the boundaries of the plumes. An 11-km (6.8-mi) pipeline connects the extraction well heads to the Effluent Treatment Facility (ETF) (Figure 2-1). The ETF removed the primary contaminants of concern (technetium-99 and uranium), as well as the secondary contaminants of concern (carbon tetrachloride and nitrate).

The entire 200-UP-1 Groundwater OU addresses conditions and plumes beneath the southern third of the 200 West Area and adjacent portions of the surrounding 600 Area. Additional information on 200-UP-1 pump-and-treat operational history and contaminant source background is presented in Appendix A.

2.1 FISCAL YEAR 2003 ACTIVITIES AND DEVELOPMENTS

Several important changes occurred at the 200-UP-1 Groundwater OU and pump-and-treat system in FY03, including the following:

- The 200-UP-1 OU pump-and-treat system was reconfigured. Well 299-W19-39 operated continuously throughout the year, paired initially with well 299-W19-36, and later with 299-W19-43. Well 299-W19-43 was converted to an extraction well during the period from May 15 through 22, 2003. Well 299-W19-36 then temporarily operated as a monitoring well until late FY03, when it was reconfigured again as an extraction well to provide backup extraction capacity. These additions to extraction well 299-W19-39 ensure that the system meets the long-term production requirement of 189.3 L/min (50 gallons per minute [gpm]).
- A new monitoring well, 299-W19-46, was drilled in November 2002 near well 299-W19-38, south of the baseline plume area. During drilling, samples were taken at 6-m (20-ft) intervals to establish a vertical profile of contaminant distribution in the unconfined aquifer. Quarterly sampling was conducted at the well in the ensuing three quarters.
- A data quality objectives (DQO) summary report (FH 2003a) was prepared for the 200-UP-1 OU to support the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remedial investigation/feasibility study (RI/FS) process by identifying data needs. A revision to the 200-UP-1 RI/FS work plan

(DOE/RL-92-76 [DOE-RL 2003b]) was also initiated during FY03 and is scheduled for completion in FY04.

- A sampling and analysis plan (DOE-RL 2002b), issued in FY02, was implemented for FY03 and specified a reduction in sampling frequency around the pump-and-treat baseline plume. Most baseline plume wells were sampled annually, although two were sampled semi-annually. The annual sampling was performed in January 2003.
- Nine groundwater monitoring wells (299-W19-19, 299-W19-23 through 299-W19-26, 299-W19-28 through 299-W19-30, and 299-W19-38) and one vadose well (299-W19-90) around the baseline plume at 200-UP-1 were decommissioned in FY03. These wells were decommissioned according to WAC standards
- Work continued in FY03 on a geochemical model being developed by MSE Technology Applications, Inc., of Butte, Montana, to meet a recommendation presented in the 5-year review (EPA 2001) to provide information for the 200-UP-1 RI/FS process. The model will attempt to explain the behavior of uranium in both the unsaturated soil column and in groundwater, from the start of waste discharge in 1952 to the present. Activities performed to date include geologic characterization of the Hanford and Ringold units beneath the site, field measurements of parameters controlling uranium sorption, borehole logging, and extensive batch tests to assess uptake of uranium in different chemical forms and interferences of other cations and anions at a variety of soil pH levels. An initial round of batch testing was used to calibrate the numerical model. A second round of batch tests were run in FY03 to improve the calibration and accuracy of the numerical model. A final report will be prepared in FY04 and the results will be presented in the FY04 annual report for 200-UP-1 OU.

2.2 EXTRACTION SYSTEM PERFORMANCE

The ETF reported processing 98,344,000 L (25,980,000 gal) of groundwater in FY03. Table 2-1 provides quarterly information on the volume of treated groundwater and contaminant mass removed since initiation of 200-UP-1 OU pump-and-treat operations. The individual extraction wells' daily production rates are shown in Figure 2-2, and the average rates are summarized in the table below. This table is based only on pumping rates when the system is running; downtime for scheduled and unscheduled outages has been factored out. For the individual well pairs, average extraction rates were measured for the stated time period for the respective wells and then summed. For the year, the combined extraction system averaged 178.2 L/min (47.1 gpm).

Well	299-W19-36	299-W19-39	299-W19-43
Dates of Operation	10/01/02 to 05/16/03	10/01/02 to 09/30/03	05/22/03 to 09/30/03
Average Pumping Rate for FY03, L/min (gpm)	31.0 (8.2)	143.9 (38.0)	51.0 (13.7)
Average Pumping Rate for Well Pair, 10/01/02 to 05/16/03, L/min (gpm)	177.6 (46.9)		N/A
Average Pumping Rate for Well Pair, 05/22/03 to 09/30/03, L/min (gpm)	N/A	195.7 (51.7)	

N/A = not applicable

Out of 8,760 total available operating hours in FY03, 231 hours were lost to scheduled system outages (e.g., maintenance, leachate transfers [see Appendix B], etc.) and 45 hours were lost to unscheduled system outages (e.g., major extraction well shutdown, etc.). This equates to a 96.8% availability of the extraction system, a significant improvement over FY02's 89.2% availability. Figure 2-3 depicts the monthly system availability. Unless extraction well 299-W19-39 is affected, other pump shutdowns are not considered as outages. As a result, conversions at wells 299-W19-43 and 299-W19-36 were not considered as lost time, nor was a subsequent shutdown at well 299-W19-43 through most of June 2003 to assess unexpectedly low pumping rates. A more detailed description of extraction system performance is provided in Appendix B.

2.3 TREATMENT SYSTEM PERFORMANCE

With the 98,344,000 L (25,980,000 gal) of groundwater treated in FY03, over 707,484,000 L (186,900,000 gal) have been processed at 200-UP-1 since start of pump-and-treat operations in March 1994. The quantities of uranium, technetium-99, carbon tetrachloride, and nitrate removed in FY03 and to date are presented in the table below:

Contaminant	FY03 Totals	Totals Since Startup, March 1994
Uranium (kg)	21.2	179.5
Technetium-99 (g [Ci])	11.8 [0.2]	102.0 [1.73]
Carbon tetrachloride (kg)	2.8	25.7
Nitrate (kg)	4,158	27,344

The ETF process generated a total of 461 – 208-L drums (55-gal drum size) of powder waste, 9 – 208-L drums of sludge waste, and 18 m^3 of contact waste. The ETF process efficiencies are reported at 100% for uranium, technetium-99, and carbon tetrachloride, and at >99.9% for nitrate. A comparison of the primary and secondary contaminants in the influent and effluent at the ETF are presented in Figure 2-4. Uranium, technetium-99, carbon tetrachloride, and most nitrate concentrations in the treated effluent were below detection levels. An estimated 5.8 kg of

carbon tetrachloride were lost to the atmosphere in transport between the well heads and the treatment system. Carbon tetrachloride lost in transit between the 200-UP-1 well heads and the ETF is not reportable because it is a continuous release that is routine, anticipated, and incidental to normal operations and treatment processes (40 *Code of Federal Regulations* [CFR] 302).

2.4 CONTAMINANT MONITORING

The technetium-99 and uranium plumes are defined by sample results from wells around the baseline plume location. Carbon tetrachloride and nitrate plumes are more extensive and cover most of the 200 West Area. Reductions to secondary contaminants' plume sizes and mass reductions from treatment at the 200-UP-1 OU are beneficial but of minor impact to the 200 West Area plumes.

The 200-UP-1 contaminant trend plots for influent as measured at extraction wells 299-W19-36, 299-W19-39, and 299-W19-43 are shown in Figure 2-5.

2.4.1 Technetium-99 and Uranium Monitoring Results

As shown in the table below, the baseline plumes of technetium-99 and uranium declined during FY03. The RAO plume configuration for technetium-99 and uranium (presented in Figures 2-6 and 2-7) is based on the results of a sampling event on January 20 and 21, 2003, and represents the most complete data set for the FY. Based on technetium-99 sampling data from January 2003, only well 299-W19-43, at 18,200 pCi/L, exceeded the RAO of 9,000 pCi/L. Once established as an extraction well, 299-W19-43's technetium-99 concentration rapidly dropped to 3,390 pCi/L. With this change, the technetium-99 plume has dropped below the RAO levels. Future sampling will demonstrate if the decline is a temporary or permanent condition. Appendix D presents trend plots for all wells associated with the 200-ZP-1 OU.

Well	Type	FY03 Frequency	Tc-99 (pCi/L)		Uranium (µg/L)	
			FY03	FY02	FY03	FY02
299-W19-20	Monitoring	Annual	838	1,140	459	581
299-W19-35	Monitoring	Annual	795	568	42.7	41.4
299-W19-36	Extraction/ monitoring	Annual	4,600	8,915	453	995
299-W19-37	Monitoring	Semi-annual	436 and 808	605	249 and 284	261
299-W19-39	Extraction	Annual	952	1,160	223	134
299-W19-40	Monitoring	Annual	170	219	127	150
299-W19-43	Monitor/ extraction	Semi-annual	18,200 and 3,390	22,400	1,190 and 480	1,560
299-W19-46[a]	Monitoring	Quarterly	163, 154, 174, and 139	N/A	131, 168, 164, and 105	N/A

[a] For well 299-W19-46, the first value for each analyte concentration is from undeveloped well during vertical profile sampling.

Based on January 2003 sampling results, uranium values at all of the wells have declined to below RAO values (480 µg/L), except at well 299-W19-43 where the uranium concentration was 1,190 µg/L. Concentrations at this well then declined to 480 µg/L following conversion to an extraction well. Thus, for FY03, the uranium plume is defined by a single 480-µg/L result at well 299-W19-43, and technetium-99 has dropped below the RAO level.

A sharp concentration decline at well 299-W19-43 is the suspected result of converting the well from a monitoring to extraction function. The 18,200 pCi/L technetium-99 and 1,190 µg/L uranium concentrations in January 2003 were measured while the well was configured for monitoring. The 3,390 pCi/L technetium-99 and 480 µg/L uranium concentrations from the July 2003 sampling event were measured with the well pumping at 46 L/min (12.2 gpm). By comparison, the annual sampling at well 299-W19-36 was performed while the well was pumping at 30 L/min (7.9 gpm). As discussed below, nitrate levels also declined. Although an overall decline for each analyte would likely to have occurred, the sharp decline observed is attributed to pumping at the well removing contaminated groundwater and drawing in less contaminated parts of the plume. Since 1999, the capture zone from well 299-W19-39 has extended past the baseline plume area (DOE-RL 2000). In addition, well 299-W19-36 first discharged treated water to the aquifer in this area and then extracted groundwater with elevated concentrations of the contaminants.

Some monitoring wells in the 200-UP-1 baseline plume have exhibited rapid increases to a peak value, followed by rapid declines in concentrations. The peak-and-decline behavior was discussed in detail in *Fiscal Year 2002 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations* (DOE-RL 2003a) and is attributed to remobilization of contaminants from the vadose zone. A rebound test to evaluate the stability of contaminants in the groundwater could be used to plan future treatment actions.

Although uranium and technetium-99 concentrations are slowly declining at most wells, a few wells are exhibiting increases in contaminant levels. At wells 299-W19-35 and 299-W19-37, technetium concentrations increased to 795 pCi/L and 808 pCi/L, respectively, which are increases of 37% and 85% over the respective FY02 values. Similarly, the second of the semi-annual uranium concentrations increased by 14% (to 284 µg/L) at well 299-W19-37 and by 14% (to 223 µg/L) for the annual sample results at well 299-W19-39 when compared to FY02 results. Additional sampling will demonstrate if the increases represent changes in trends or if the increases are a function of contaminant variability in the aquifer.

2.4.2 Secondary Contaminant Monitoring Results

Nitrate is present in the 200 West Area as two large plumes exceeding the 45 mg/L DWS. Within the 200-UP-1 OU, this plume is derived from discharges to wastes sites 216-U-1 and 216-U-2, which lie due west of the 200-UP-1 pump-and-treat system. Carbon tetrachloride is derived primarily from discharges to waste sites 216-Z-1A, 216-Z-9, and 216-Z-18 in the 200-ZP-1 Groundwater OU and has spread beneath most of the 200 West Area. Carbon tetrachloride concentrations around the 200-UP-1 baseline plume are much less than the 2,000 µg/L RAO values used at 200-ZP-1 but are consistently above the 5 µg/L DWS. In most wells, concentrations of carbon tetrachloride and nitrate are stable or declining. Well 299-W19-43 was sampled for nitrate for the first time in FY03. Nitrate concentrations were 1,980,000 µg/L in January 2003 but declined to 784,000 µg/L in July 2003. The highest concentration of carbon tetrachloride was 270 µg/L at well 299-W19-36.

2.5 AQUIFER RESPONSE

Aquifer response is an important component in assessing the effectiveness of the pump-and-treat system. Water-level measurements provide the basis for assessing the control pumping exerts over the flow around the plumes. Coupled with the knowledge of aquifer properties, it also helps to predict the capture zone of the pumping system.

2.5.1 Hydraulic Monitoring

Groundwater flow in the 200-UP-1 is generally west to east with a hydraulic gradient of 0.001 m/m. As shown in Figure 2-8, the current flow pattern indicates a slow change from the west-northwest/east-southeast flow regime active in the 1995 baseline. Impacts from discharges to liquid waste sites are diminishing as the present flow direction more closely approximates the regional flow in the 200 West Area and the western part of the Hanford Site. Small impacts of extraction well pumping on monitoring well water levels were observed during the year.

Groundwater elevation data collected during FY03 at locations away from the extraction wells but within the 200-UP-1 pump-and-treat monitoring network indicate that the groundwater surface declined at an average of 0.38 m/yr (1.25 ft/yr). This is essentially the same rate of decline as FY02's 0.36 m/yr (1.2 ft/yr) but is significantly less than 0.66 m/yr (2.2 ft/yr) reported for FY98. The decline began with cessation of discharges to the 216-U-10 Pond in 1985 and continued following a Sitewide halt of liquid waste disposal to low-level waste streams to the soil column in 1995. Declining groundwater levels are hindering the ability to maintain the 189.3 L/min (50 gpm) extraction rate specified in the interim ROD (EPA et al. 1997). Minor discharges to the soil column continue at sanitary tile fields and through leaking water lines. A pipeline leak in June 2003 released unknown but relatively small quantities of water to the soil column at a location approximately 70 m (230 ft) west of the 216-U-1/2 Cribs. Additional discussion of hydraulic monitoring is presented in Appendix C.

2.5.2 Numerical Modeling

Numerical modeling has been used to calculate capture zones around the extraction wells, as shown in Figure 2-9. Appendix E provides additional information about groundwater modeling. Modeling results indicate that the extraction wells are capturing contaminants in the baseline plume area. The streamlines and 180-day travel markers for the capture zones around the three wells represent the approximate location of a water particle at 180-day intervals in the past. For ease of calculation, modeling of the capture zone for two extraction wells was started in FY02 rather than building from capture zone analyses in previous annual modeling. As a result, Figure 2-9 presents the appearance that a central portion of the plume is not being captured and is not under the influence of well 299-W19-39. In fact, the long-term effects of pumping at well 299-W19-39 (since October 1996) are being continued and have been accelerated with secondary extraction from upgradient wells 299-W19-36 and 299-W19-43. These wells capture from the area where the technetium-99 and uranium plumes were above RAOs in the FY02 annual report (DOE-RL 2003a).

Additional proof of plume capture is evident by long-term, below-RAO contaminant concentrations at compliance wells 299-W19-35, 299-W19-40, and at 299-W19-37. Well 299-W19-46, located adjacent to decommissioned well 299-W19-38, also provided an additional check by monitoring technetium-99 and uranium concentrations along the southern edge of the

plume previously tracked by the older well. Well 299-W19-38 went dry in January 2000 with concentrations of technetium-99 at 750 pCi/L and uranium at 213 µg/L. With the startup of monitoring at well 299-W19-46, technetium-99 and uranium concentrations have not exceeded 175 pCi/L or 170 µg/L.

The FY98 annual report (DOE-RL 1999) contained a calculation of the length of time that the extraction well pump at 299-W19-39 could be shut down before high-concentration contaminants would move from the well to beyond the downgradient capture zone. Using an assumed groundwater flow velocity of 0.68 m/day (2.23 ft/day), it was concluded that the pump could be shut down for up to 73 days before technetium-99 exited the capture zone. This calculation has not been repeated in FY03.

2.6 CONCEPTUAL MODEL UPDATE

This section provides an update of the conceptual model for technetium-99 and uranium at the 200-UP-1 groundwater pump-and-treat system, as presented in *Hydrogeologic Conceptual Model for the Carbon Tetrachloride and Uranium/Technetium-99 Plumes in the 200 West Area: 1994 Through 1999 Update* (BHI 1999). A quantitative geochemical model for uranium distribution is being prepared by MSE Technology Applications, Inc. and will be completed in FY04. The results of this model will be presented in the FY04 annual report. Additional process history information is presented in Appendix A.

Uranium, technetium-99, and nitrate were discharged to the 216-U-1/216-U-2 Cribs between 1952 and 1967 as minor constituents in 46.2 million L (12.2 million gal) of waste discharged from the 221-U and 224-U Plants. The 216-U-1/216-U-2 Cribs are two 3.7-m by 3.7-m by 1.2-m (12-ft by 12-ft by 4-ft)-high, open, wooden cribs placed 22.8 m (75 ft) apart in excavations 6 m (20 ft) deep. Wastewater from the 221-U and 224–U Facilities first passed through the 241-U-361 settling tank, in which precipitated and particulate matter was retained. Liquids then went to the 216-U-1 Crib and overflowed to the 216-U-2 Crib if flow rates were great enough. A number of waste streams from within each plant and process were sent to these cribs, and it is difficult to determine a dominant source for the waste streams. Acidic decontamination wastes were discharged to the cribs in the 1966-1967 timeframe.

The Waste Information Data System (WIDS) database reports that an estimated 4,040 kg of uranium were discharged to the soil column, along with $1.2 \times 10^{+6}$ kg of nitrate. Technetium-99 mass sent to the cribs is reported to be 0.00068 Ci (0.04 g) (Diediker 1999). Neither technetium-99 nor nitrate are retarded by chemical reactions with the soil column. Uranium possesses a range of retardation values depending on its chemical form, varying from immobile as a phosphate to highly mobile in others.

The two waste sites have been characterized several times, notably in 1985 (Delegard et al. 1985, Baker et al. 1988) in response to high uranium concentrations in groundwater beneath the cribs, and again in 1994 (DOE-RL 1996a) during 200-UP-2 OU characterization activities. The highest concentrations of uranium are found in the Hanford formation soil column immediately beneath the column, declining with depth until reaching the Plio-Pleistocene silt unit and caliche layer. At these fine-grained units, increased concentrations of uranium are observed. These units slowed down or prevented downward flow and led to a concentration of uranium building up at 48.8 to 52 m (158 to 170 ft) below ground surface (bgs). Significant concentrations of uranium in the underlying Ringold sediments are not reported. Elevated uranium concentrations in groundwater were detected in February 1985 (Delegard et al. 1985, Baker et al. 1988) and

were associated with operation of the 216-U-16 Crib (see Appendix A). A pump-and-treat system was operated at the 241-S evaporator between June and November 1985 that recovered 687 kg of uranium. Between this mass and the 197.5 kg of uranium removed by the pump-and-treat systems since 1994, approximately 21% of the total uranium discharged to the cribs has been recovered. Significantly more technetium-99 has been removed from groundwater (102 g) than was reported discharged to the cribs (0.04 g).

Groundwater flow in the 200 West Area is generally from west to east. The water table level has been declining since 1985 but at slowly decreasing rates. At present, at least one waste site, the 2607-W5 sanitary drain field (located within 50 m [165 ft] of the 216-U-1/216-U-2 Cribs), is discharging low volumes of liquids to the soil column. Leaks from raw water lines close to the source cribs were reported in the FY02 annual report (DOE-RL 2003a), but remobilization of contaminants has not been observed. Another much smaller leak was reported west of the FY02 leak in June 2003, but quantities of water released are not available.

Extraction rates are declining at groundwater wells around the 200-UP-1 OU pump-and-treat system. The aquifer is presently within the Ringold Unit E, a fluvial deposit with zones of more productive sand and gravel units interbedded with finer-grained, less productive silty sands. At present, pumping rates at extraction well 299-W19-39 have declined by 25%, from 190 to 144 L/min (50 to 38 gpm), between 1998 and 2003. In this timeframe, the groundwater table has declined 2.7 m (9 ft). Geologic control on pumping rates is evident only at well 299-W19-36, as the groundwater elevation coincides with thin beds of sand. Otherwise, sandy gravels comprise the aquifer in wells 299-W19-39 and 299-W19-43.

The plume maps (Figures 2-6 and 2-7) are based on annual sampling results from January 2003. At that time, both technetium-99 and uranium concentrations were below the RAO levels of 9,000 pCi/L and 480 µg/L, respectively, at all wells but 299-W19-43. Technetium-99 concentrations at this well declined to below the RAO in July 2003 sampling, which followed startup of well 299-W19-43 as an extraction well. Uranium concentrations were at the RAO for this well. It is uncertain if concentrations will rebound when pumping is stopped. With technetium-99 and uranium at or below their respective RAOs, a 6- to 12-month rebound study should be conducted in FY05.

In general, uranium and technetium-99 have been assumed to occur in the upper 10 m (32.8 ft) of the aquifer. Data from well 299-W19-46, located south of the baseline plume, supports this assumption for uranium and carbon tetrachloride. For both constituents, the highest values are within the upper 10 to 15 m (33 to 50 ft) of the aquifer at well 299-W19-46. However, for technetium-99 and nitrate, the highest concentrations were found 18.3 to 24.4 m (60 to 80 ft) below the top of the groundwater table. Geologic control of the highest concentration sample (1,360 pCi/L at 19.6 m [64 ft] below the groundwater table) was evident. The next highest concentration (715 pCi/L at 25.7 m [84 ft]) below the groundwater table was at the contact of a 1.5-m (4.9-ft)-thick silty sand overlying a sandy gravel.

2.7 QUALITY ASSURANCE/QUALITY CONTROL

Replicate (duplicate) laboratory analyses were performed on 5% of groundwater samples collected across the 200-UP-1 Groundwater OU in FY03, although none of the wells were within the baseline plume area. The duplicate samples are compared for precision using the relative percent difference (RPD) calculation for each sample pair (see Appendix G). The EPA

guidelines indicate that an RPD of 20% or less is a satisfactory indicator of analytical precision. For the 200-UP-1 OU, the table below summarizes the results of the RPD calculation:

Type of Quality Control Sample	Number of Pairs	Number of Pairs <20% RPD	Percentage <20% RPD
Offsite laboratory replicates	12	9	75%

The results indicate that 25% of the samples exceeded the 20% RPD guideline. An examination of supporting data indicates that none of the results were close enough to minimum detection limits to warrant a more statistically valid test. Of interest is that two of these samples were from the same well in consecutive quarters, but for two different analytes (i.e., uranium and technetium-99).

2.8 TECHNETIUM-99 AT WELL 299-W23-19

Groundwater containing high concentrations of technetium-99 is also being collected at well 299-W23-19, in the 241-SX Tank Farms, and treated at the ETF (see Appendix F). Effective March 12, 2003, in accordance with an agreement between the U.S. Department of Energy (DOE) and the Washington State Department of Ecology (Ecology), quarterly sampling at this well was accompanied by the capture of large volumes (>3,785 L [>1,000 gal]) of contaminated groundwater. The groundwater was taken to the ETF by truck and combined with water received from the 200-UP-1 extraction wells. During FY03, the well was sampled five times, the last three of which were accompanied by purgewater collection. The trend plot for technetium-99 concentrations is presented in Figure 2-10 and shows a peak in January 2003 at 188,000 pCi/L, followed by a substantial decline to 74,300 pCi/L in September 2003.

The following table presents data on the accumulated volume of purgewater and the concentration of the initial sample. From this information, the technetium-99 curie content was calculated and converted to a mass value using the specific activity value of 0.017 Ci/g. As the table indicates, a total of approximately 0.001 Ci of technetium-99 (or 0.067 g) has been recovered. The diminishing concentrations suggest that the plume has moved downgradient from the well's capture zone.

Date of Sampling	Groundwater Pumped, L (gal)	Technetium-99 Concentration (µg/L)	Curies of Technetium-99[a]	Mass of Technetium-99 (g)
March 12, 2003	2,722 (719)	133,000	0.00036	0.021
June 18, 2003	4,028 (1,064)	120,000	0.00048	0.028
September 23, 2003	4,013 (1,060)	74,300	0.00030	0.018

[a] Specific activity of technetium-99 is 0.017 Ci/g, or 58.7 g/Ci.

The March 12, 2003, groundwater collection did not meet the desired goal of 3,785 L (1,000 gal). Sediment filtration to below 5 microns is an acceptance requirement at the ETF to treat wastewater. Filters on the purgewater truck clogged during pumping and limited the total groundwater extracted to 2,722 L (719 gal). The filtration system was modified and extracted

volumes have since surpassed the 3,785 L (1,000 gal) goal. The *Hanford Site Groundwater Annual Report for Fiscal Year 2003* (PNNL 2004) presents a more detailed discussion of technetium-99 monitoring at this well.

2.9 CONCLUSIONS

Measurable progress was made toward meeting the specific RAOs for the 200-UP-1 OU pump-and-treat interim remedial measure operation for FY03. Each RAO is discussed below:

- ***RAO #1: Reduce contamination in the areas of highest concentrations of uranium and technetium-99 to below 10 times the cleanup level under MTCA for uranium and 10 times the MCL for technetium-99.***

  Results:

  - Technetium-99 plume: Significant progress has been made in remediating the baseline technetium-99 plume. Concentrations at all of the wells in the baseline plume area were below the 9,000 pCi/L RAO. Sampling in FY04 will verify if the aquifer's responses to extraction are temporary or permanent changes, particularly at wells 299-W19-36 and 299-W19-43.

    Extraction wells 299-W19-36 (at 4,600 pCi/L), 299-W19-39 (at 952 pCi/L), and 299-W19-43 (at 18,200 and 3,390 pCi/L) have all shown decreases over the FY02 concentrations. The remaining wells (299-W19-20, 299-W19-35, 299-W19-37, 299-W19-40, and 299-W19-46) used for monitoring are all below the MCL value of 900 pCi/L. Well 299-W19-35, located downgradient along the northern part of the plume, has increased to 795 pCi/L from 379 pCi/L in early 1999. Well 299-W19-37 is also increasing and is now at 808 pCi/L, up from 523 µg/L in July 2001.

  - Uranium plume: Significant progress has also been made in remediating the baseline uranium plume. Concentrations at all monitoring and extraction wells are below the RAO, except at well 299-W19-43 where the uranium concentration is equal to the RAO value of 480 µg/L. Well 299-W19-35 (at 42.7 µg/L) is below the baseline MCL concentration of 48 µg/L. Wells 299-W19-20 (459 µg/L [now dry]) and 299-W19-36 (453 µg/L) are close to the RAO concentrations. The remaining wells show concentrations that are between the RAO and MTCA levels. Of the wells, 299-W19-39 is at its highest concentration (223 µg/L) since October 1999 and well 299-W19-37 is at its highest level (284 µg/L) since October 2000.

    From the above data for technetium-99, all wells in the baseline plume have declined below the 9,000 pCi/L RAO. Throughout FY03, the uranium plume was above the RAO at only one well. Future sampling will determine if the observed trends for technetium-99 and uranium are temporary or permanent. In FY04, semi-annual samples will be taken at extraction and monitoring wells close to the baseline uranium plume.

- ***RAO #2: Reduce potential adverse human health risks through reduction of contaminant mass.***

  Results: Contaminant mass remaining in the groundwater was reduced during FY03. Over 98 million L (25 million gal) of groundwater were treated by the ETF in FY03 and resulted in removal of the following contaminant mass in FY03 and from FY94 to date:

Contaminant	FY03	Total Since March 1994
Technetium-99	11.8 g	102.0 g
Uranium	21.2 kg	179.5 kg
Carbon tetrachloride	2.80 kg	25.7 kg
Nitrate	4,158 kg	27,344 kg

  An estimated 5.8 kg of carbon tetrachloride were lost to the atmosphere while pumping the groundwater from the extraction wells to the Liquid Effluent Retention Facility (LERF). The ETF's treatment efficiencies were greater than 99.9% for all contaminants.

  Unscheduled downtime for the extraction wells amounted to 3.2% of the total scheduled time available for operations. Extraction well 299-W19-39 provided between 75% and 85% of the total water treated. Well 299-W19-36 provided approximately 15% of the volume during operation from October 2002 to May 2003, while well 299-W19-43 provided 25% of the extracted groundwater from July to September 2003.

- ***RAO #3: Prevent further movement of these contaminants from the highest concentration area.***

  Results: The highest technetium-99 (>9,000 pCi/L) and uranium (>480 µg/L) concentration portion of the plumes appear to be hydraulically contained based on data from downgradient wells 299-W19-37 and 299-W19-40. Monitoring well 299-W19-46 has helped to delineate the southern extent of the two plumes, but low well density to the north increases the uncertainty of plume boundaries. Observed increases in concentrations of technetium-99 at well 299-W19-35 will be compared against the FY04 sample results and the two new wells to be installed in FY04 and FY05, which will be upgradient of well 299-W19-35.

- ***RAO #4: Provide information that will lead to development and implementation of a final remedy that will be protective of human health and the environment.***

  Results: FH continued to collect operational and groundwater monitoring data to support development and implementation of a final remedy. Well 299-W19-46 was installed in November 2002 and was sampled to determine the vertical distribution of contaminants within the upper 36.5 m (120 ft) of the aquifer. The results are described in the conceptual model (Section 2.6). This well has provided a southern boundary data point for the MCL concentration of the technetium-99 plume, as well as a bound on the extent of the uranium plume.

  An activity to model uranium behavior in unsaturated sediments and groundwater will be completed in FY04. The work is being performed by MSE Technology Applications, Inc., under contract to DOE. A combined field and laboratory testing program has been completed and final modifications to the geochemical model have been made. A final report discussing the geochemical controls governing the movement of uranium will be prepared in FY04.

2.10 RECOMMENDATIONS

Based on the FY03 pump-and-treat system operational and monitoring data, the following recommendations for the 200-UP-1 OU are presented.

- **Perform a 6- to 12-month-long rebound study in FY05 to confirm that technetium-99 and uranium concentrations will remain below the RAO concentrations.**

  Technetium-99 concentrations have decreased to below the 9,000 pCi/L RAO at all wells in the baseline plume area. Uranium has also decreased to below the 480 µg/L RAO concentration at all but one well (299-W19-43) in FY03, where it equaled the RAO concentration. If uranium and technetium-99 remain below the RAO at all wells in FY04, a plan will be developed to assess how the contaminants might rebound in the absence of pumping.

  A rebound study observes changes in the groundwater contaminant concentrations of a contaminant over time, following cessation of groundwater extraction. Concentration increases may result as the contaminant desorbs from the soil matrix and pore spaces and dissolves in the groundwater. The reaction is controlled by the chemical form of the contaminant, soil and sediment properties, and groundwater characteristics. Technetium-99 has not been observed to be chemically retarded at Hanford. Uranium occurs in waste streams in a variety of chemical forms and exhibits different levels of sorption, or mobility, in groundwater.

  When pumping is halted, bi-weekly sampling may be required for the first month to measure contaminant concentrations; thereafter, monthly sampling will be required. Sampling frequency can be lengthened if contaminant response indicates no dramatic increases in trends. All extraction and baseline monitoring wells should be sampled. Previous calculations have shown that with a cessation of pumping at well 299-W19-39, loss of control of contaminants indicated by increases in concentrations would take 73 days to show up at downgradient monitoring well 299-W19-40. Rapid increases at wells may indicate the potential loss of control of the plume and may necessitate restarting the pumps. If the rebound study is stopped prior to a full 6- or 12-month term, routine sampling described in the next bullet should be resumed.

  To accomplish this task, regulatory approval would be needed. The data from the rebound study could be used to help support the RI/FS risk assessment modeling.

- **Increase frequency of monitoring and extraction well sampling at the 200-UP-1 OU.**

  Quarterly performance monitoring sampling was specified in the *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan* (DOE-RL 1997) and implemented through FY02. Performance monitoring requirements for the 200-UP-1 pump-and-treat system were not considered during the DQO process leading to the *Sampling and Analysis Plan for the 200-UP-1 Groundwater Monitoring Well Network* (DOE-RL 2002b) in FY03 and led to annual sampling. Adjustments have been made to achieve semi-annual sampling in FY04, as presented in the 200-UP-1 RI/FS work plan (DOE-RL 2003b), but the project is now responsible for performance monitoring at extraction wells.

The ETF treats 200-UP-1 wastewater and is responsible for its own sampling and analysis program. Sampling at the extraction wells is still required, as these wells provide the most direct evidence of plume remediation. Their locations have been selected to hydrologically capture the high-level portions of the plume. Well 299-W19-39, the longest running and most productive of the wells, is located near the downgradient edge of the baseline plume. Wells 299-W19-36 and 299-W19-43 have most recently been the high-concentration center of the FY02 plume and have shown dramatic decreases in concentration of both uranium and technetium-99 during FY03. The carbon tetrachloride concentrations from these wells also helps compute the mass lost in pumping between the extraction wells and the ETF/LERF. These wells should be sampled quarterly and at other points in time in which the well is either being added to or removed from the extraction system.

Monitoring wells are used to estimate the margins of the plumes. Although some are located in key positions to detect the movement of contaminants past extraction wells, the data are regarded as less crucial than extraction well sampling data. Semi-annual sampling at these five wells should be suitable unless marked changes are detected.

Figure 2-1. 200-UP-1 Site Location Map and Monitoring Wells.

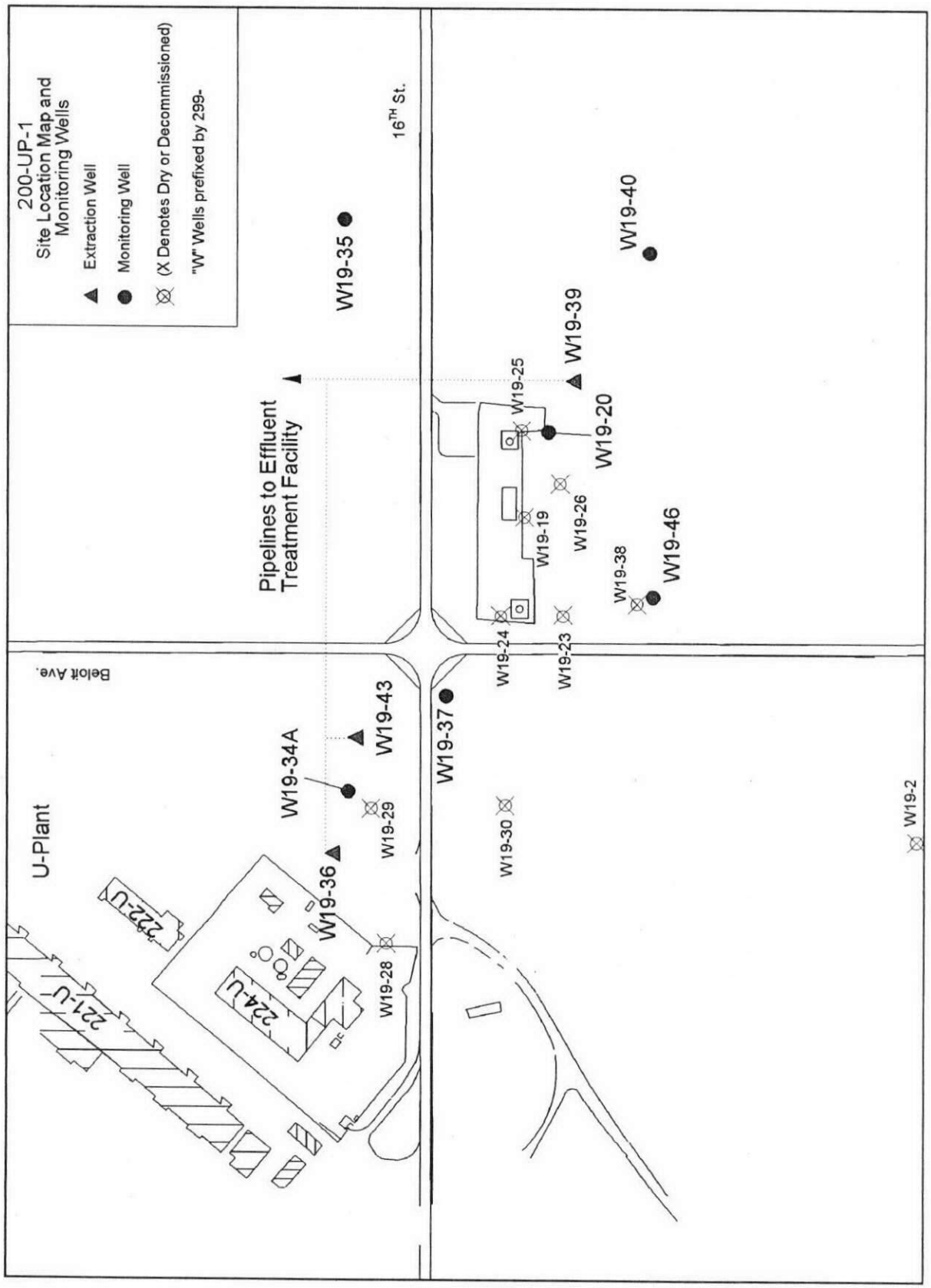


Figure 2-2. Extraction Rate Averages at 200-UP-1 Operable Unit.

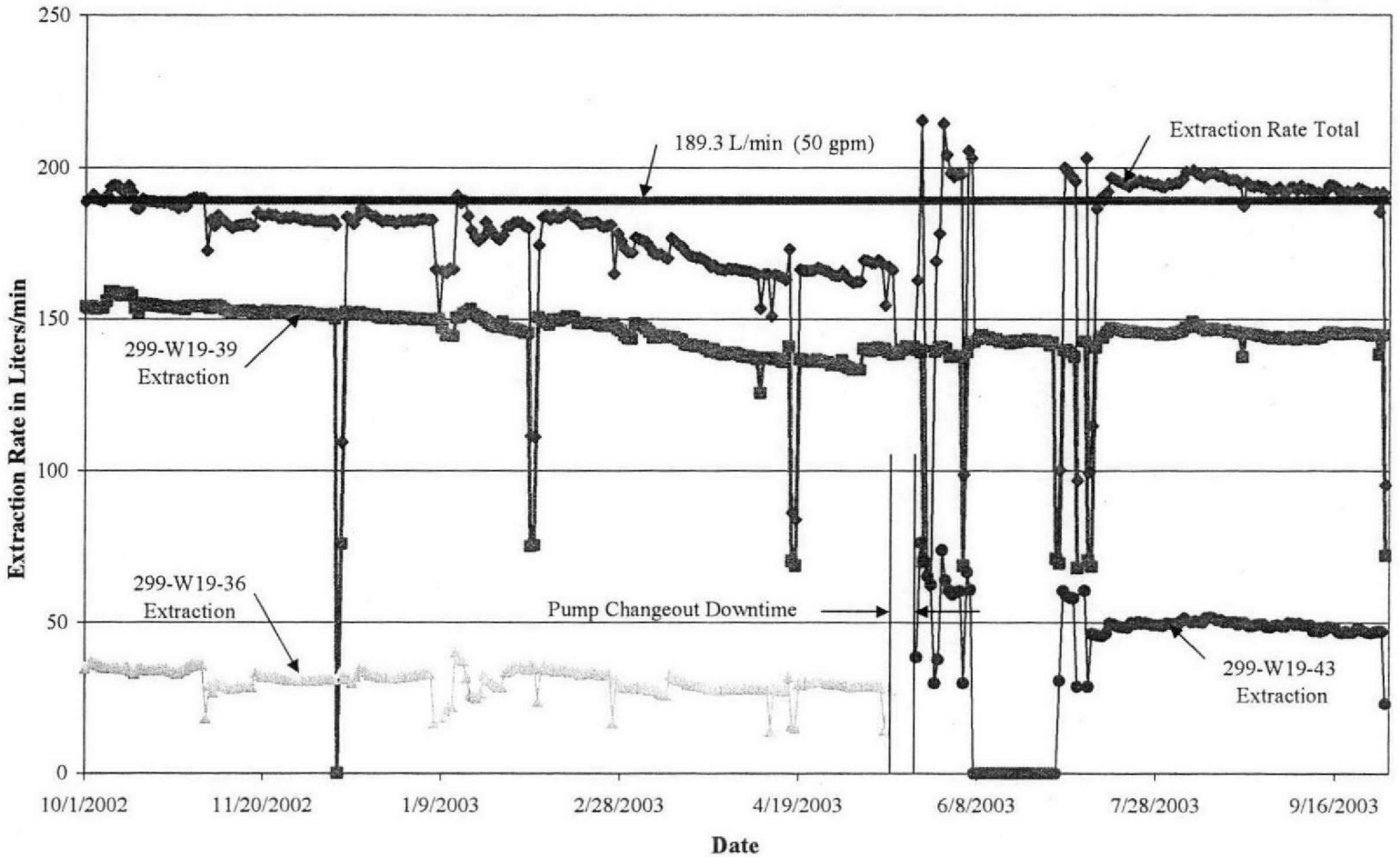
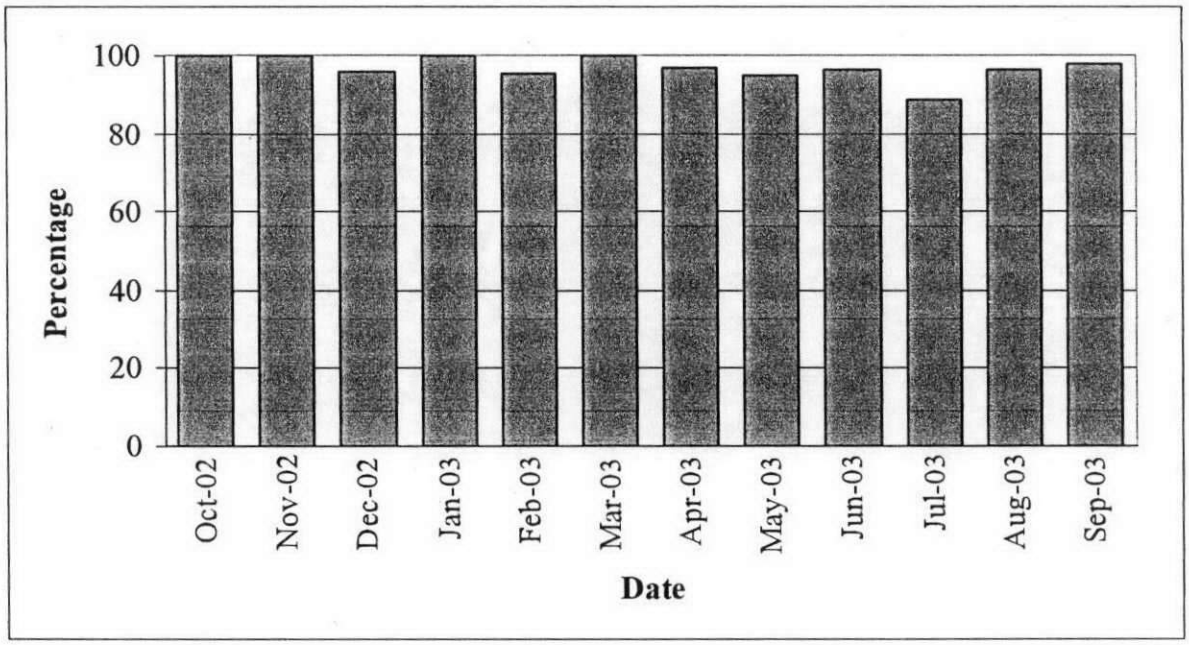


Figure 2-3. 200-UP-1 Operable Unit Pump-and-Treat System Availability.



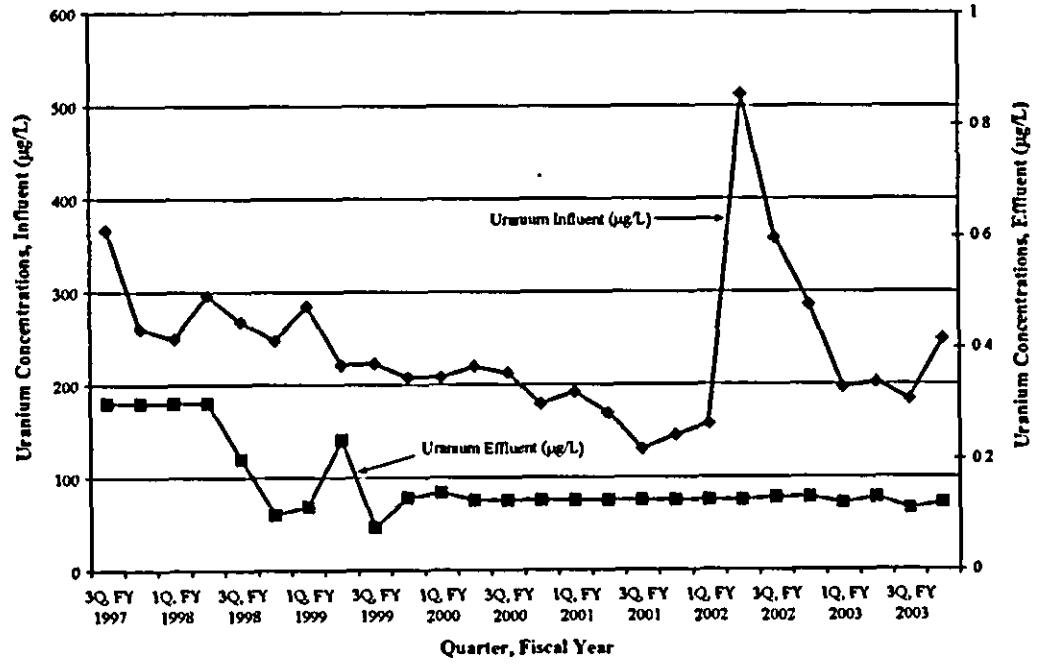
System availability:

Total hours in FY03 = 8,760 hours
Total time available during FY03 (total hours minus scheduled outages) = 8,529 hours
Total time on-line during FY03 (total hours minus all outages) = 8,484 hours
System on-line availability ({total time on-line/total hours} x 100) = 96.8%
Total system availability ({total time available/total hours} x 100) = 99.4%

Scheduled and unscheduled system outages:

12/11 to 12/12/02	System shut down for 26.5 hours for leachate transfer.
02/03/03	Unscheduled outage. System shut down for 11 hours due to low water level in extraction well.
02/26 to 02/27/03	System shut down for 19.5 hours for leachate transfer.
04/17 to 04/18/03	System shut down for 25.5 hours for leachate transfer.
06/02/03	System shut down for 1 hour maintenance.
06/04/03	System shut down for 24 hours due to leachate transfer.
06/30/03	System shut down for approximately 28.5 hours in support of changeout of pump at extraction well 299-W19-43.
07/06/03	System shut down for 11 hours by the Effluent Treatment Facility.
07/07 to 07/13/03	System shut down for 8 hours due to a power outage. System shut down for 24 hours for Environmental Restoration Disposal Facility (ERDF) leachate transfer.
08/06/03	System shut down 23 hours for ERDF leachate transfer.
09/30/03	System shut down 8 hours for ERDF leachate transfer.

Figure 2-4. 200-UP-1 Operable Unit Trend of Influent/Effluent Contaminant Concentrations as Measured by the Effluent Treatment Facility. (2 sheets)



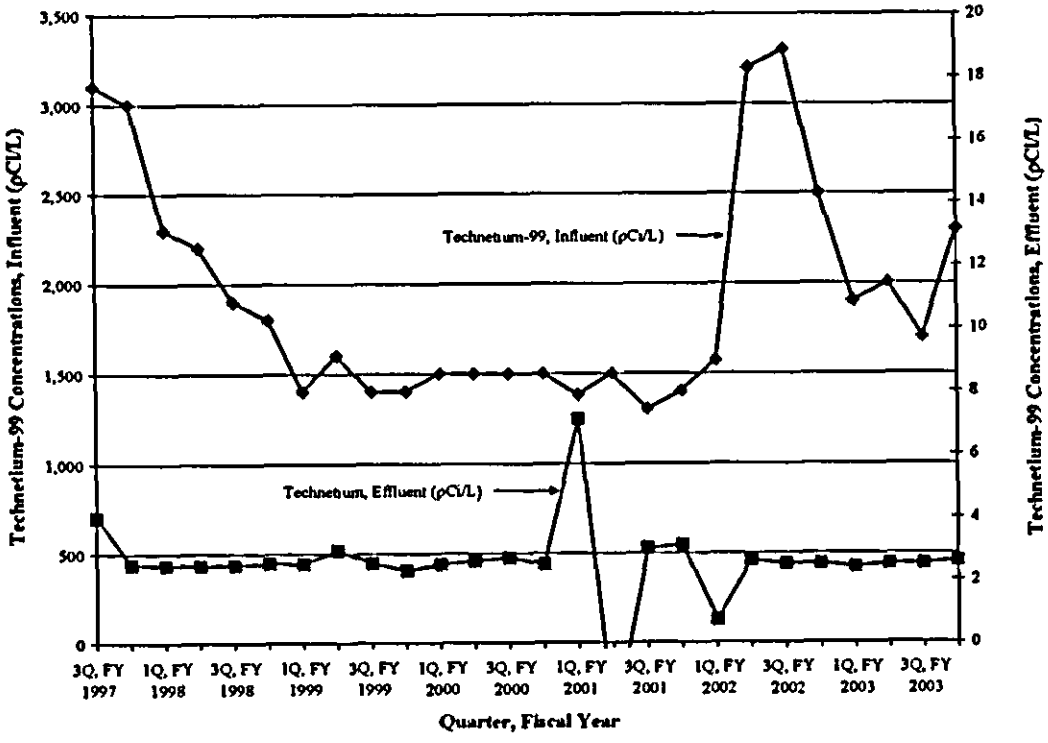
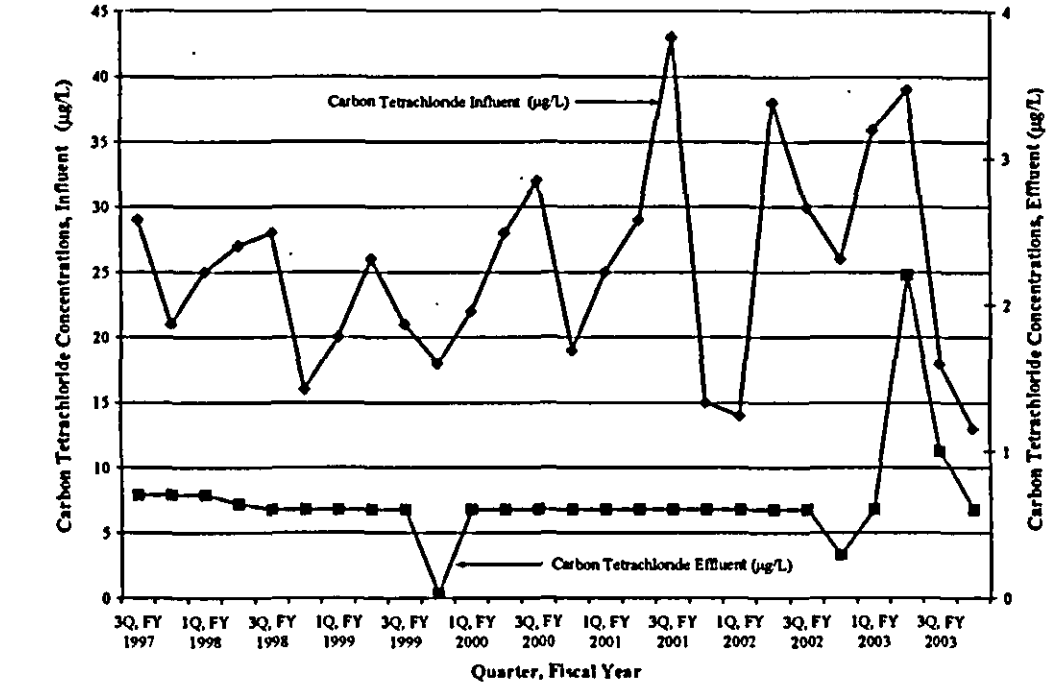


Figure 2-4. 200-UP-1 Operable Unit Trend of Influent/Effluent Contaminant Concentrations as Measured by the Effluent Treatment Facility. (2 sheets)



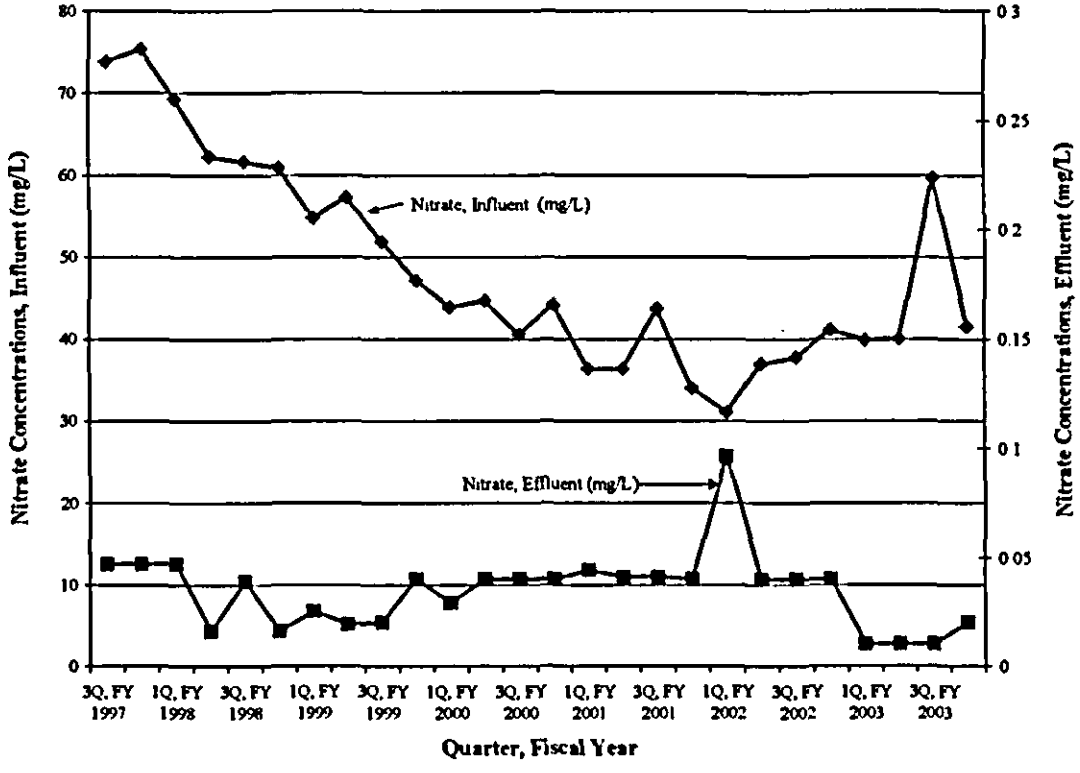
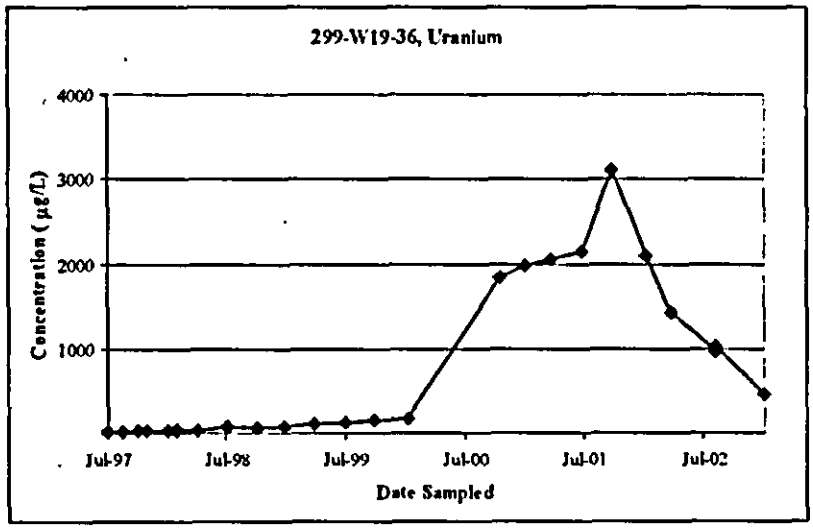
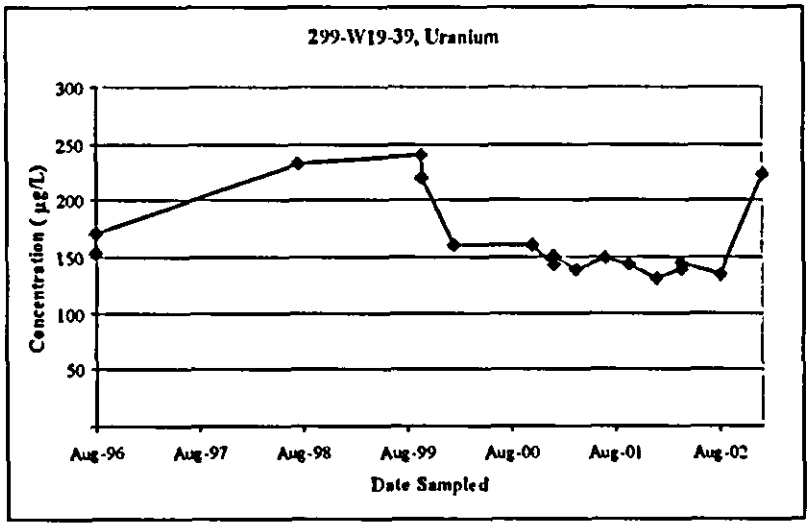


Figure 2-5. 200-UP-1 Operable Unit Contaminant Trend Plots for Influent as Measured at Extraction Wells 299-W19-36, 299-W19-39, and 299-W19-43. (3 sheets)





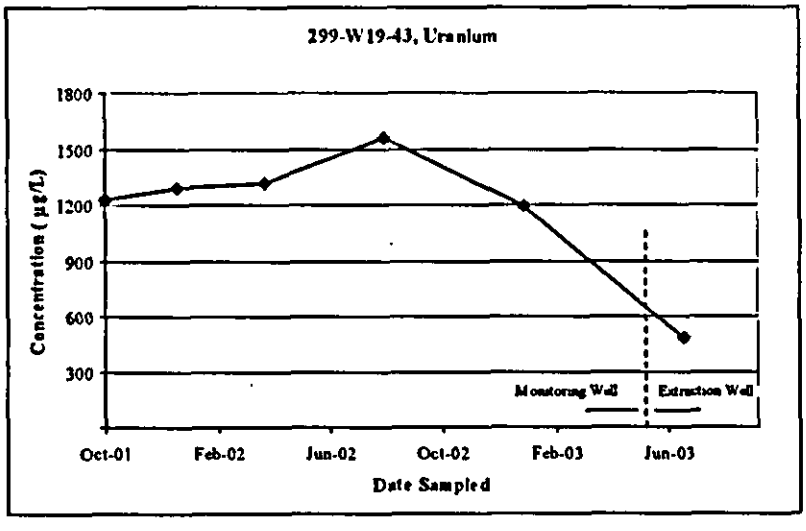
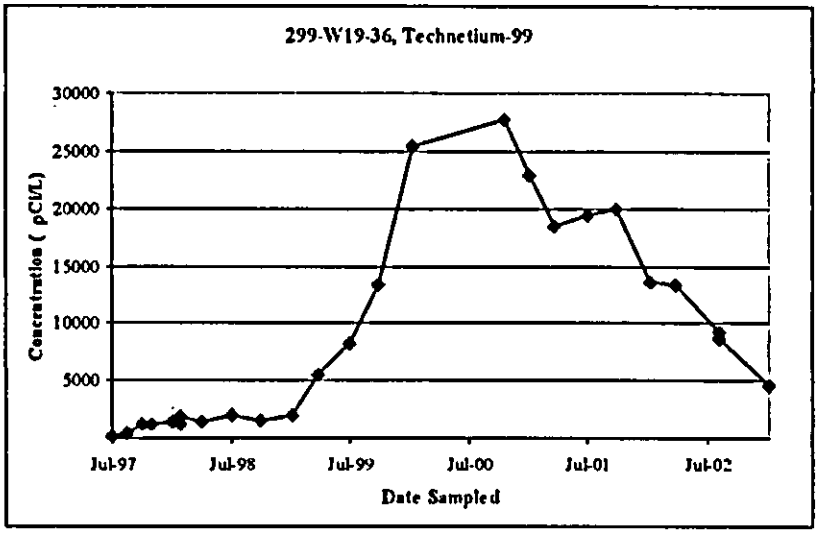
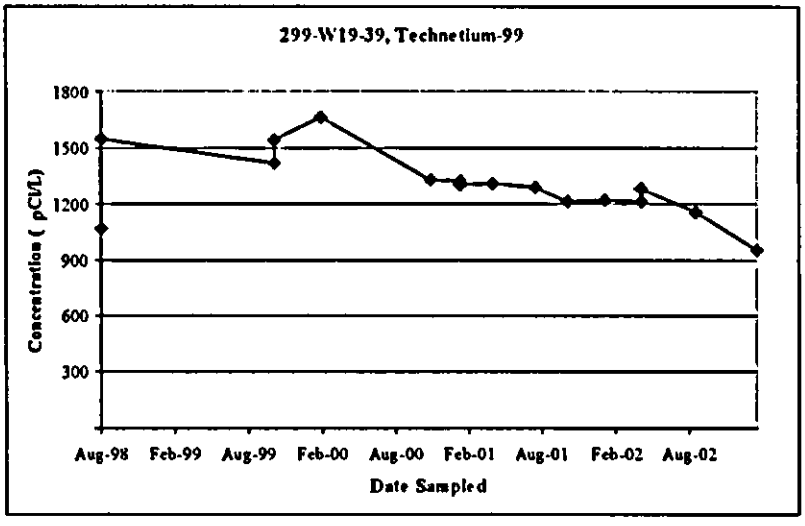


Figure 2-5. 200-UP-1 Operable Unit Contaminant Trend Plots for Influent as Measured at Extraction Wells 299-W19-36, 299-W19-39, and 299-W19-43. (3 sheets)





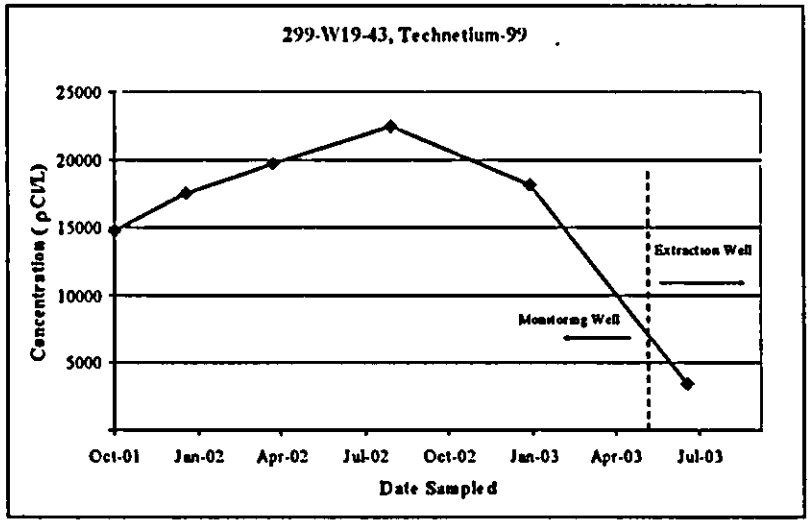
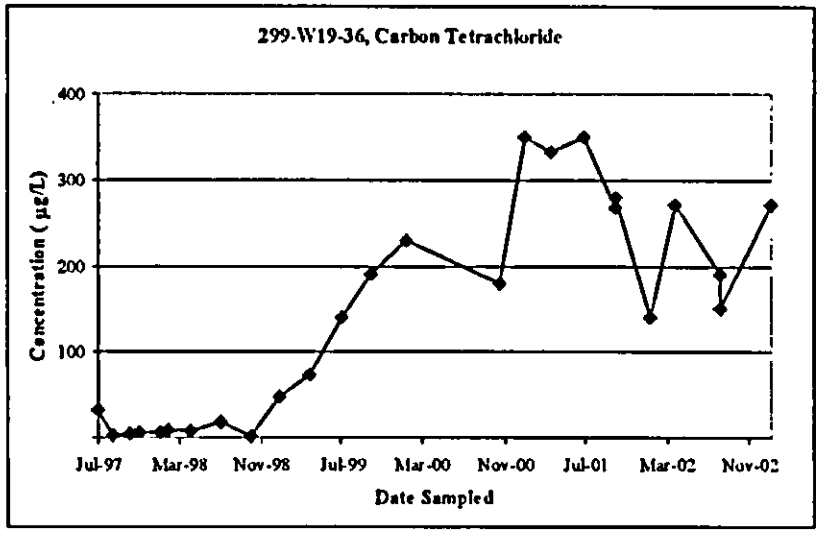
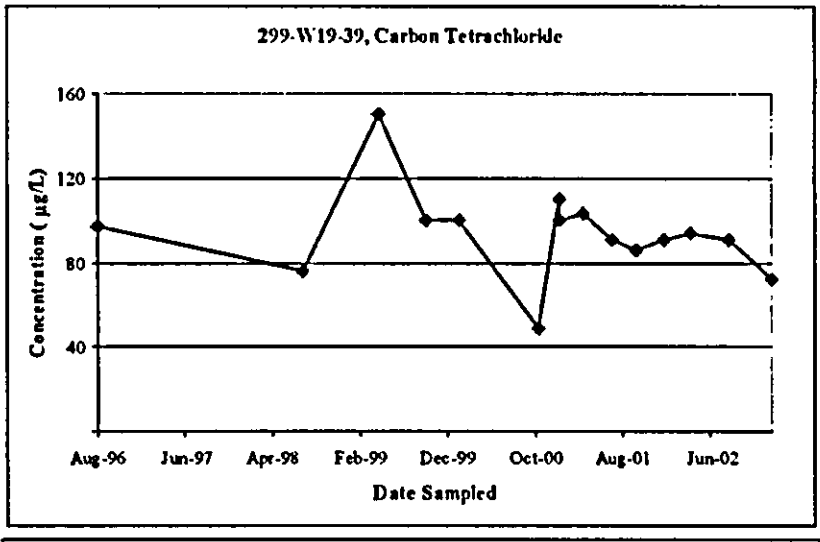


Figure 2-5. 200-UP-1 Operable Unit Contaminant Trend Plots for Influent as Measured at Extraction Wells299-W19-36, 299-W19-39, and 299-W19-43. (3 sheets)





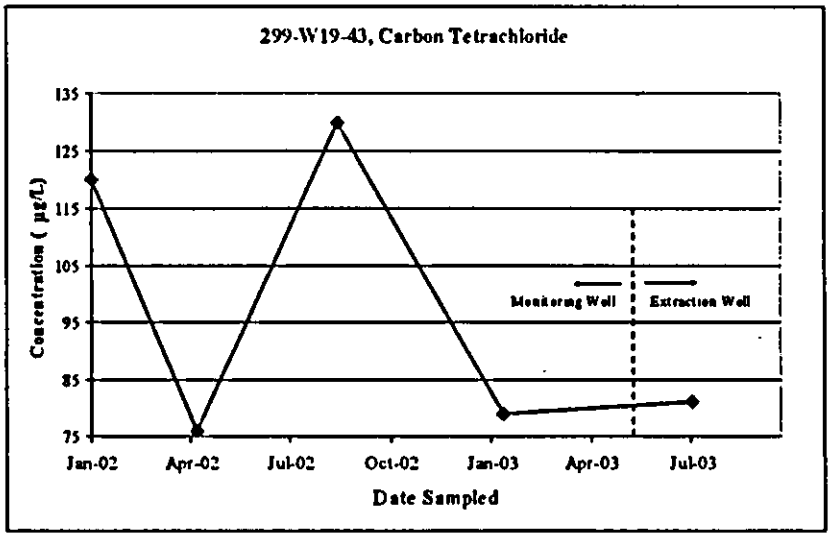


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Figure 2-6. 200-UP-1 Operable Unit Technetium-99 Contaminant Plume.

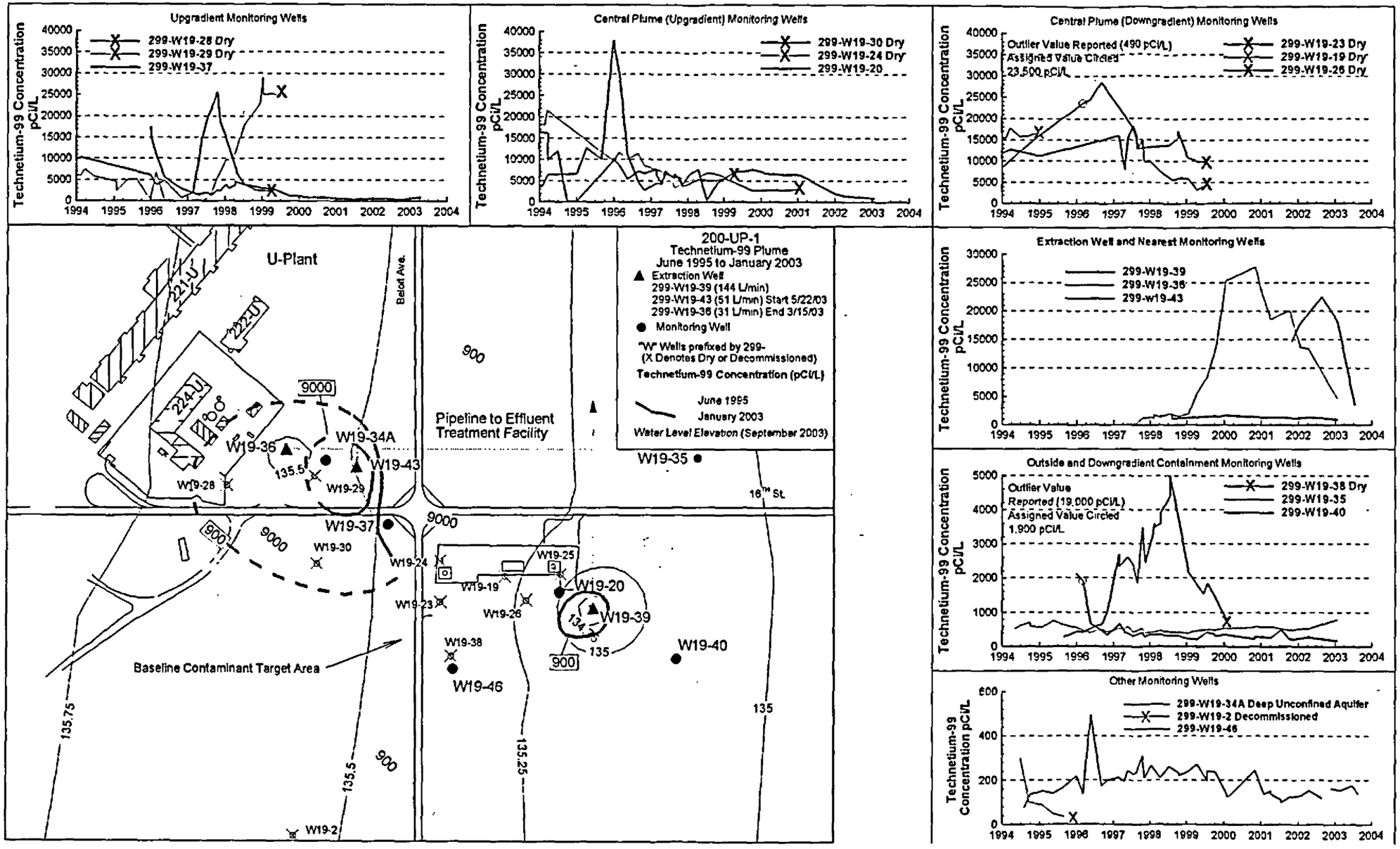

Figure 2-7. 200-UP-1 Operable Unit Uranium Contaminant Plume.

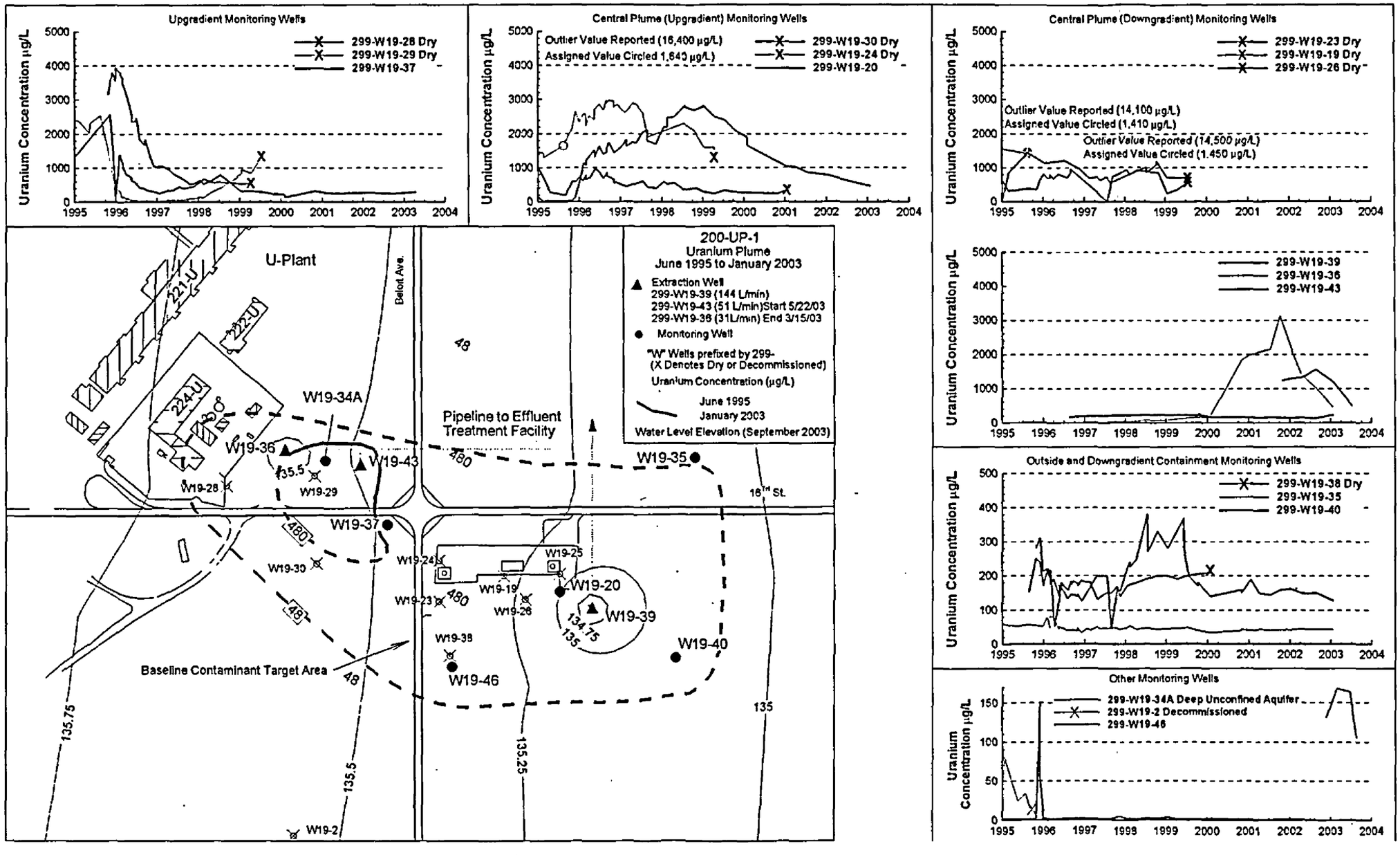

Figure 2-8. 200-UP-1 Operable Unit Water Table Map: Baseline Water Table June 1995 Versus September 2003 Water Table.

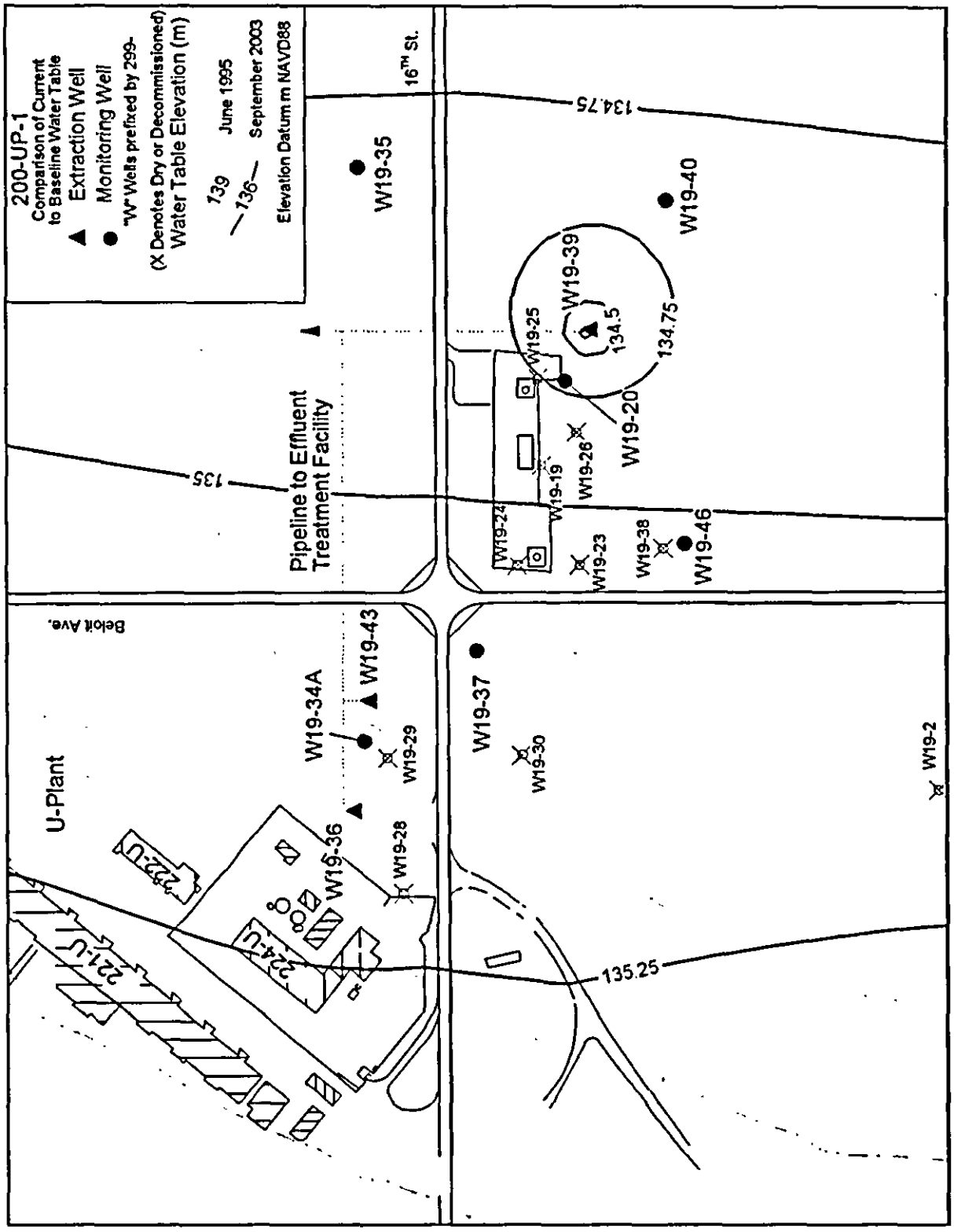

Figure 2-9. 200-UP-1 Operable Unit Area of Hydraulic Capture Through September 2003.

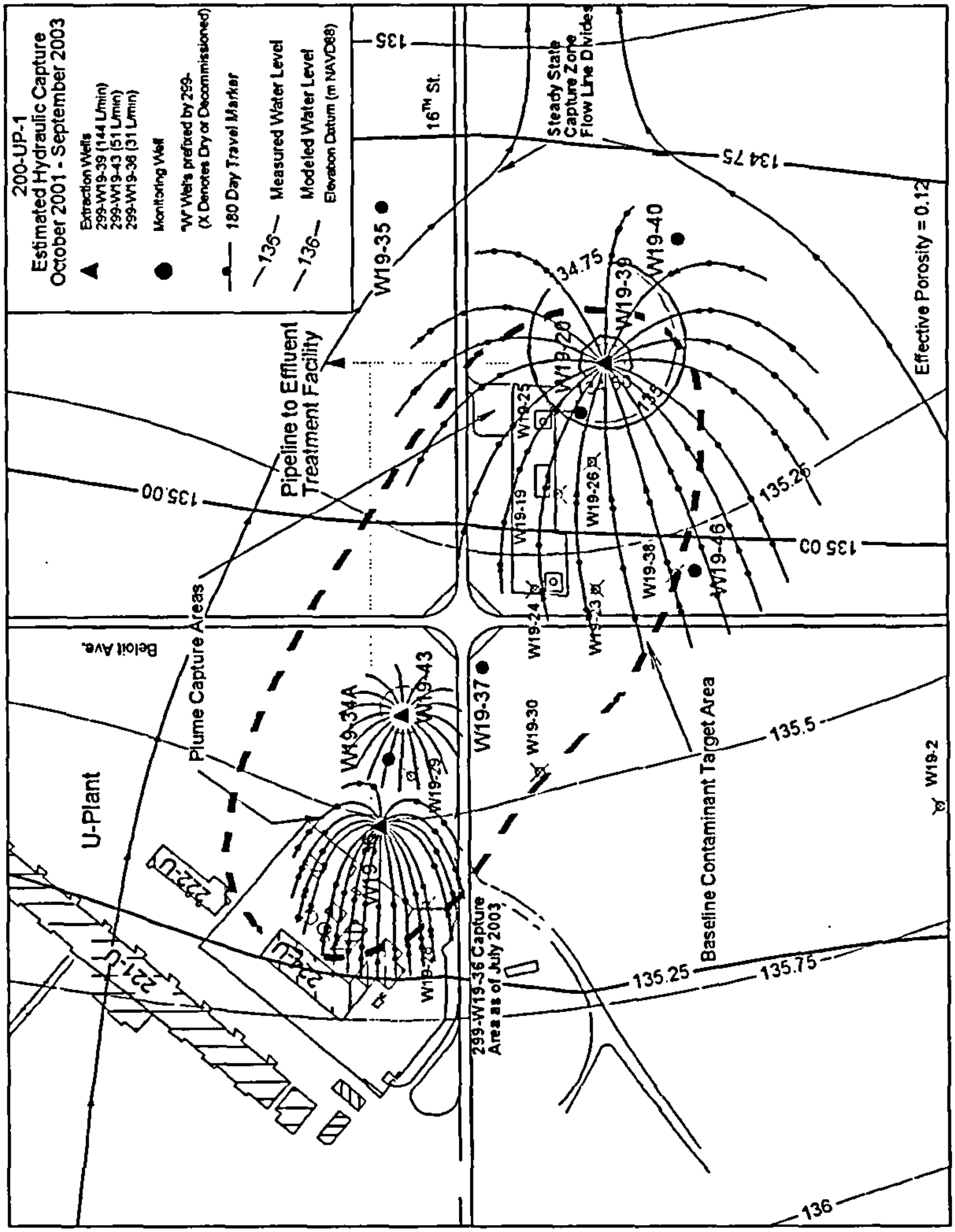

Figure 2-10. Technetium-99 Trend Plot at Well 299-W23-19.

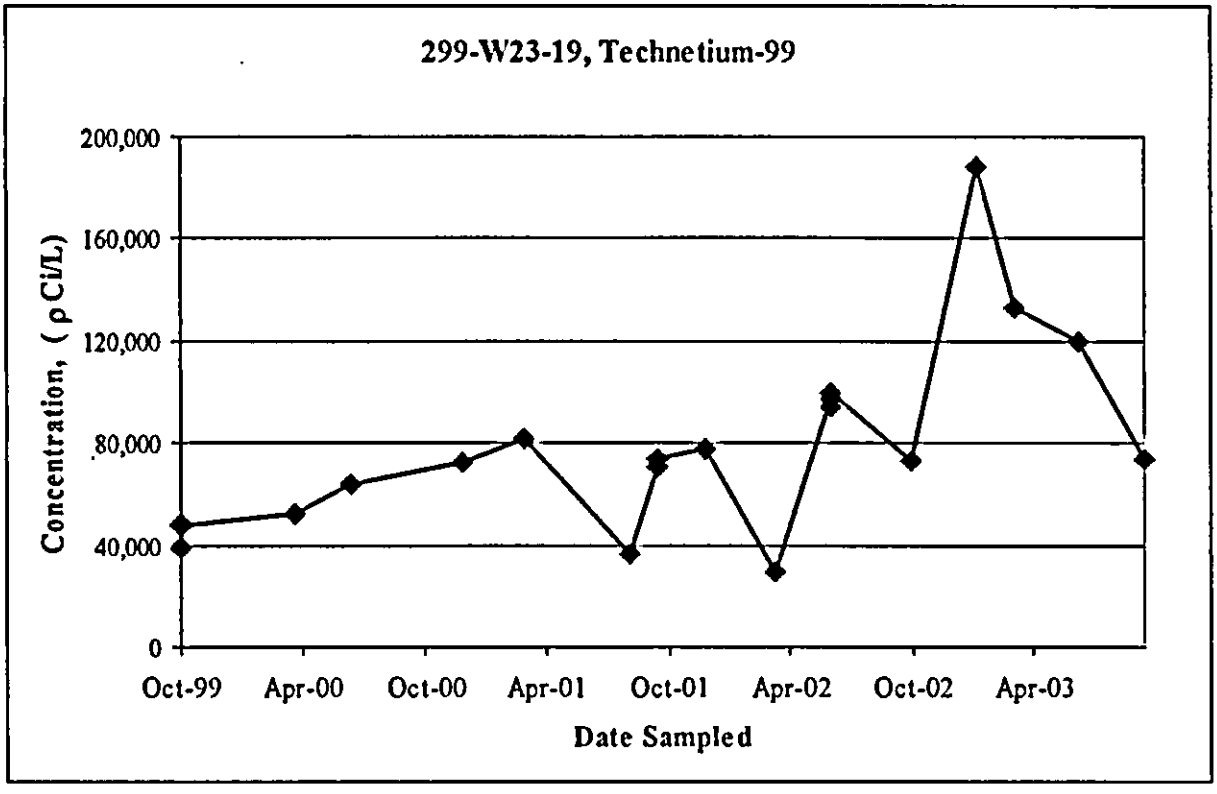

Table 2-1. Volume of Groundwater Treated and Mass of Contaminants Removed Since Initiation of Operations at the 200-UP-1 Operable Unit. (2 sheets)

Dates	Liters Treated	Mass Tc-99 Removed (g)	Mass Total Uranium Removed (g)	Mass Carbon Tetrachloride Removed (g)	Mass Nitrate Removed (kg)
March 1994 – November 1994[a]	3,898,550	3.41	4,422	Not reported	N/A
December 1994 – August 1995	11,391,491	7.79	9,831	992	N/A
September 1995 – November 1995	17,198,571	3.95	3,895	630	N/A
December 1995 – March 1996	31,311,340	9.05	9,105	1,609	N/A
April 1996 – June 1996	22,459,108	5.4	6,845	1,569	N/A
July 1996 – September 1996	22,370,327	4.01	5,134	2,790	N/A
October 1996 – December 1996	20,300,000	3.33	5,607	2,980	N/A
January 1997 – February 1997[b]	2,667,600	0.83	963	73	N/A
February – March 30, 1997	Shut down	N/A	N/A	N/A	N/A
March 31 – September 30, 1997	32,414,481	5.6	11,000	888	2,260
October 1 – December 31, 1997	20,390,054	3.31	6,300	572	1,530
January 1 – March 31, 1998	19,791,765	2.08	4,900	460	1,070
April 1 – June 30, 1998	33,538,750	3.58	8,680	907	2,150
July 1 – September 30, 1998	26,346,466	1.57	3,750	296	900
October 1 – December 31, 1998	22,174,396	1.49	4,910	341	979
January 1 – March 31, 1999	23,720,542	1.89	4,450	601	1,050
April 1 – June 30, 1999	24,369,400	2.29	5,400	600	1,400
July 1 – September 30, 1999	23,206,922	2.14	5,940	460	1,430
October 1 – December 31, 1999	14,858,190	1.25	3,080	286	681

Table 2-1. Volume of Groundwater Treated and Mass of Contaminants Removed Since Initiation of Operations at the 200-UP-1 Operable Unit. (2 sheets)

Dates	Liters Treated	Mass Tc-99 Removed (g)	Mass Total Uranium Removed (g)	Mass Carbon Tetrachloride Removed (g)	Mass Nitrate Removed (kg)
January 1 – March 31, 2000	14,636,480	1.29	3,100	352	645
April 1 – June 30, 2000	18,295,080	1.63	4,050	527	806
July 1 – September 30, 2000	15,439,630	1.45	3,410	494	675
October 1 – December 31, 2000	35,538,203	2.93	6,475	781	1,371
January 1 – March 31, 2001	17,352,328	1.41	3,332	434	631
April 1 – June 30, 2001	24,300,159	2.01	3,798	833	955
July 1 – September 30, 2001	25,284,628	2.02	3,523	696	967
October 1 – December 31, 2001	31,276,969	2.8	4,840	444	987
January 1 – March 31, 2001	6,102,084	2.54	4,350	854	850
April 1 – June 30, 2002	31,217,155	6.05	11,400	950	1,180
July 1 – September 30, 2002	17,290,247	3.11	5,830	499	669
October 1-December 31, 2002	23,365,000	3.19	5,980	359	966
January 1-March 31, 2003	24,550,000	2.90	5,210	699	991
April 1-June 30, 2003	28,615,000	3.31	5,747	1,087	1,144
July 1-September 30, 2003	21,813,000	2.39	4,238	654	1,056
Totals	**707,483,916**	**102.00**	**179,494**	**25,717**	**27,344**

[a] Data from the treatability test as reported in the *Treatability Report for the 200-UP-1 Operable Unit – Hanford Site* (DOE-RL 1995).
[b] Estimated values based on 189 L/min flow, running 24 hours/day, at 97.5% efficiency.
FY = fiscal year
N/A = not applicable

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3.0 200-ZP-1 OPERABLE UNIT PUMP-AND-TREAT SYSTEM

The 200-ZP-1 OU pump-and-treat system is located near the middle of the 200 West Area (Figure 3-1) and is centered on a plume formed by discharges to four waste sites located south and east of the 234-5Z Plutonium Finishing Plant (PFP). The broader 200-ZP-1 Groundwater OU includes groundwater plumes associated with the 234-5Z PFP, 221-T Plant, and waste sites located in the northern half of the 200 West Area. The pump-and-treat system is operated to capture and treat the primary contaminant of concern (carbon tetrachloride) and secondary contaminants (chloroform and TCE).

This section provides the annual performance report required by the *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* (EPA et al. 1995). The system's process flow is shown in Figure 3-2. Appendix A presents the history of the pump-and-treat system and a synopsis of the waste site operations.

3.1 FISCAL YEAR 2003 ACTIVITIES AND DEVELOPMENTS

During FY03, a variety of activities were undertaken at the 200-ZP-1 pump-and-treat system to improve system operation and understanding of contaminant behavior.

- The primary activity at the 200-ZP-1 OU was addressing the issue of declining pumping rates at the extraction wells. Since 1996, pumping rates at wells 299-W15-33 and 299-W15-32 (Figure 3-1) have decreased by 50% to 70%. The primary cause of this is a decline in groundwater table elevation. Extraction wells 299-W15-32 and 299-W15-33 will be replaced with new wells completed with longer screens spanning a greater thickness of the unconfined aquifer. Well 299-W15-45 was drilled to replace well 299-W15-33 in the third quarter of FY03. A replacement for well 299-W15-32 will be drilled in FY04. Both wells will be connected to the extraction system and are expected to begin operation in spring 2004. In each case, the replacement well is located within 5 to 10 m (approximately 15 to 30 ft) of the original extraction well.
- In November 2002, a new monitoring well, 299-W15-43, was drilled west of the 241-TX/TY Tank Farms, adjacent to the 216-T-25 Cribs. The boring was drilled to a depth of 106.3 m (348.8 ft) bgs and backfilled to 82.5 m (270.7 ft). A 10-cm (4-in.)-diameter by 11-m (35-ft) well screen was installed between 68.9 to 79.9 m (229.3 to 262.2 ft) bgs. Prior to backfilling, sampling was conducted at approximately 6-m (20-ft) intervals to investigate the vertical distribution of contaminants. A carbon tetrachloride concentration of 3,300 µg/L was observed at 14.9 m (49 ft) below the water table. The results are discussed in Section 3.6.2.
- Two *Resource Conservation and Recovery Act of 1976* (RCRA) wells located along the west side of the 241-TX/TY Tank Farm complex were sampled for carbon tetrachloride in FY03. Well 299-W15-44, located between the southwest corner of the 241-TX Tank Farm fence line and extraction well 299-W15-34, was sampled in August 2003 and yielded a carbon tetrachloride concentration of 2,900 µg/L. This well has been added to the 200-ZP-1 monitoring well list for FY04. Well 299-W15-765, located near the northwest corner of the TY Tank Farm, was sampled twice in FY03, yielding carbon tetrachloride concentrations of 3,300 and 3,200 µg/L.

- The sampling and analysis plan for a new borehole at the 216-Z-9 Trench characterizing the vadose zone and aquifer for dense nonaqueous phase liquid (DNAPL) was developed in FY04 (DOE-RL 2004a, Appendix E). The well is located along the south side of the trench, approximately 3 to 5 m (10 to 15 ft) from the trench's concrete cover.
- The sampling design to investigate the potential presence of additional vadose zone sources of carbon tetrachloride contamination was developed in FY03 (DOE-RL 2004a, Appendix D). The investigation includes groundwater and soil vapor sampling in the areas of locally elevated carbon tetrachloride groundwater concentrations. Sampling will be conducted in FY04 as part of the 200-PW-1 OU dispersed carbon tetrachloride vadose zone plume remedial investigation.
- Several wells are approaching the end of their service life. Well 299-W18-24 went dry in FY03, and well 299-W15-16 is estimated to have less than 2 years of service remaining. It will be replaced in the monitoring network with nearby well 299-W15-30.
- Three wells (299-W15-10, 299-W15-19, and 299-W15-25), which were previously part of the 200-ZP-1 pump-and-treat monitoring system, were decommissioned.
- A DQO summary report and a work plan for the 200-ZP-1 OU have been prepared to support the RI/FS process. *Data Quality Objectives Summary Report Supporting the 200-ZP-1 Operable Unit Remedial Investigation/Feasibility Study Process* (FH 2003a) was released in July 2003. Work on the *Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit* (DOE-RL 2004b) was initiated late in FY03 and will be completed in late FY04.
- In FY03, DOE initiated a study to determine whether carbon tetrachloride is present in DNAPL form in the 200 West Area. Three contractors are developing conceptual models, as well as proposed methods to prove the models, which are being evaluated for further study. One of the models will be selected, with that contractor tasked to confirm its conceptual model. The project is scheduled for completion in FY06.

3.2 EXTRACTION SYSTEM PERFORMANCE

For the year, the five extraction wells produced an average of 513 L/min (135 gpm), approximately 10% less than the target extraction rate of 567.8 L/min (150 gpm). For FY03, the extraction wells produced 253.6 million L (67 million gal), bringing the total volume of groundwater pumped since 1994 to 2.15 billion L (568 million gal) (see Table 3-1). With wells 299-W15-33 and 299-W15-32 operating at low production rates and additional downtime at these wells for part of FY03, an 11.7% reduction in the volume of treated water resulted when compared to FY02's 573 L/min (151 gpm). Based on field analytical results, carbon tetrachloride concentrations were lower for FY03 annual averages at four of the five extraction wells. For well 299-W15-34, carbon tetrachloride concentrations increased slightly, an effect attributed to well 299-W15-33 being off-line from August to November 2002.

For the individual wells, FY03 annual average pumping rates and average concentrations of carbon tetrachloride are presented in the following table. Contaminant trends for carbon tetrachloride, chloroform, and TCE are presented in Figures 3-3, 3-4, and 3-5, respectively. Additional information on the extraction well system is presented in Appendix B.

Well[a]	Average Annual Pumping Rate (L/min) {gpm}	Mean Carbon Tetrachloride Concentration (µg/L)	Minimum Carbon Tetrachloride Concentration (µg/L)	Maximum Carbon Tetrachloride Concentration (µg/L)
299-W15-33	43 {11.4}	2,709	1,900	3,200[b]
299-W15-34	77 {20.3}	5,355	2,800[b]	6,200
299-W15-35	282 {74.5}	3,233	2,200	4,000
299-W15-32	34 {9.0}	2,556	1,600	4,100
299-W15-36	77 {20.3}	1,097	900	1,800
Influent tank (T-01)	N/A	3,212	2,800	4,300
Total	513 {135.5}	--	--	--

[a] Wells listed in order from north to south.
[b] Maximum reported value 5,300 µg/L in January 29, 2003, at well 299-W15-33 and a minimum reported value of 1,973 µg/L at well 299-W15-34 were dropped based on data review qualifiers. The anomalous values suggested a mislabeling of the samples.
N/A = *not applicable*

Chloroform in groundwater has not exceeded the DWS concentration of 80 µg/L at any extraction well during FY03 or since the start of Phase II operations. Concentrations at the extraction wells ranged between 11 µg/L (well 299-W15-33) and 31 µg/L (well 299-W15-34). Except for well 299-W15-33, very small increases in average concentrations at the extraction wells were noted versus FY02 annual averages.

Average annual TCE concentrations were up slightly compared to FY02 values. The maximum concentration was 18 µg/L at well 299-W15-34. The TCE concentrations at wells 299-W15-34 and 299-W15-35 were routinely above the 5 µg/L DWS. At wells 299-W15-32, 299-W15-33, and 299-W15-36, TCE concentrations either did not exceed 5 µg/L or exceeded that concentration for only one or two samples. The minimum value was 2.0 µg/L, or nondetection values below 2 µg/L, at wells 299-W15-33 and 299-W15-36.

Contaminant concentrations at the treatment system's influent tank T-01 represent the composite average of all extraction well water entering the system. Carbon tetrachloride, chloroform, and TCE averages for FY03 are 3,212 µg/L, 18.6 µg/L, and 7.9 µg/L, respectively. The FY03 carbon tetrachloride concentration is down from the FY02 annual average by 4%, whereas the chloroform and TCE averages are slightly higher than the previous 2 years.

3.3 TREATMENT SYSTEM PERFORMANCE

The treatment system at the 200-ZP-1 OU uses an air stripper column to remove carbon tetrachloride from the groundwater by bringing it into a vapor phase. It is then captured on granular activated carbon (GAC) in canisters that are sent offsite for regeneration. Treated groundwater is returned to the aquifer through three of five injection wells located south-southwest of the treatment facility. During FY03, all five injection wells were used, but wells 299-W15-29, 299-W18-36, and 299-W18-37 were used most frequently. The schematic for the 200-ZP-1 pump-and-treat system is provided in Figure 3-2.

The 11.7% decline in total volume of groundwater extracted contributed to a 22% decrease in the amount of carbon tetrachloride removed (819.3 kg in FY03 versus 1,052.7 kg in FY02). A general decline in carbon tetrachloride concentrations at four of the five extraction wells also contributed to the decrease in mass removed. Well 299-W15-33 had a 25% decrease in average carbon tetrachloride concentration, while well 299-W15-34 had a small increase.

Treatment system availability is presented in the table below, while Figure 3-6 depicts the monthly operational availability. The treatment system is set to shut off due to low flow at 378.5 L/min (100 gpm) to protect the system in event of extraction pump failure.

Total possible run-time in a year (hours)	8,760
Total time on-line (hours)	8,342
Scheduled outages (e.g., maintenance, power outages, etc.) (hours)	250
Unscheduled outages (primarily shutdowns due to leak detection alarm shutdowns) (hours)	168
On-line availability ({total hours - total outage hours}/total hours)	95.2%
Total availability {total hours - total outage hours}/{total hours – scheduled outage hour}	98.0%

A summary of key system performance measurements are presented in the following table:

Total volume of processed groundwater:	
Total volume of groundwater processed in FY03 (millions of L)	253.6
Total volume of groundwater processed since startup (March 1994) (millions of L)	2,150
Carbon tetrachloride mass removed:	
Total mass of carbon tetrachloride removed in FY03 (kg)	819.3
Total mass of carbon tetrachloride removed since startup (March 1994) (kg)	7,668.3
Summary of FY03 operational parameters:	
Removal efficiency (% by mass, average for year – (influent - effluent)/(influent)	99.6
Removal efficiency (% by mass, average for year – (influent - adjusted effluent*)/(influent)	99.95

* Adjusted effluent – effluent sample is adjusted by subtracting field blank result from effluent sample results. See Appendix B for discussion.

Figure 3-7 presents a graphical representation of the carbon tetrachloride removal efficiency calculated by influent and effluent concentrations at the process facility.

As a check on the above calculations, removal efficiency was also computed for samples taken between October 1, 2002, and January 30, 2003, using carbon tetrachloride concentrations at injection well 299-W18-36. All concentrations at well 299-W18-36 were nondetection values of less than 2 µg/L (U). Based on this well's data, the average removal efficiency is 99.94%.

3.4 CONTAMINANT MONITORING

Data from groundwater monitoring and extraction wells around the 200-ZP-1 pump-and-treat system provide insight to the effectiveness of the groundwater remedial action. Carbon tetrachloride is the primary contaminant of concern, with chloroform and TCE as secondary contaminants. As discussed below, technetium-99 is also tracked at selected wells (between injection and extraction wells) to gauge rate of movement of treated water toward the extraction wells.

Contaminant monitoring highlights at the 200-ZP-1 pump-and-treat system for FY03 are as follows:

- Carbon tetrachloride concentrations declined at all extractions wells, except for well 299-W15-34 where a fractional increase was noted. For wells 299-W15-35, 299-W15-32, and 299-W15-36, concentrations decreased less than 9%, which is a decrease smaller than the FY02 results for the same wells. For well 299-W15-33, a 25% decline was noted in FY03.
- For the >2,000 µg/L baseline plume (Figure 3-8), while only a small change in area was noted for the >2,000 µg/L plume, the >4,000 µg/L plume shrunk noticeably and is currently centered around two wells (299-W15-34 and 299-W15-1). Four wells were greater than 4,000 µg/L in FY02. An extension of the >2,000 µg/L carbon tetrachloride plume to the north is depicted in Figure 3-9, but it is less certain if the extension is from the known waste crib sources.
- Carbon tetrachloride concentrations at well 299-W15-36 continue to be below the 2,000 µg/L RAO limit. A >2,000 µg/L concentration was last reported in July 2000, and the annual carbon tetrachloride average for this well was 1,097 µg/L in FY03. It is recommended that this well be converted into a monitoring well if the replacement wells for 299-W15-33 and 299-W15-32 can produce enough water to reach an extraction rate of 568 L/min (150 gpm) specified in the interim action ROD (EPA et al. 1995).
- Fractional increases (0.1 to 0.4 µg/L) in the average annual concentrations of chloroform were observed at all extraction wells, except for well 299-W15-33, when compared to FY02 averages. The 25 µg/L contour present in FY02 has disappeared as chloroform levels at two wells above this concentration decreased. Also, the concentration contours are somewhat smaller in area.
- Slightly higher increases (0.4 to 1.0 µg/L) in the average annual TCE concentrations were observed at wells 299-W15-34, 299-W15-35, and 299-W15-32 compared to the FY02 averages. The TCE plume contracted in width over FY03 but has also extended south to extraction well 299-W15-35 in FY03, from around well 299-W15-34 in FY02.

3.4.1 Carbon Tetrachloride Monitoring Results

Over 20 monitoring wells were sampled in FY03 to determine the carbon tetrachloride plume configuration around the treatment system (Figure 3-8). This compares to the +30 wells available in 1996 for plume monitoring. Several new wells have been drilled or added to the network, but other wells have been lost due to declining groundwater table elevations. The plume is depicted based on August 2003 data, except at well 299-W15-7 where January 2003 data were used. This adjustment was made because the August 2003 data were markedly below trend for the well, whereas the January 2003 result was regarded as being on-trend. The October 2003 results of 3,100 µg/L were similar to the January 2003 concentration of 2,900 µg/L and support the choice of discounting the August 2003 result.

The table below compares FY03 with FY02 carbon tetrachloride averages for the second quarters of each of the FYs. The data are compared only for wells where the same method of analysis, whether field or laboratory, was used to provide a more consistent basis for comparison. Typically the field analytical results are significantly higher than the laboratory results, which may be attributed to the time delays in analysis (holding times were not exceeded) that samples undergo during shipping and laboratory preparation. Well data were picked to be as close to a year apart as possible for all wells evaluated to eliminate seasonal variations. Changes to the number of wells that were sampled and analyzed between FY02 and FY03 have reduced the number of wells available for comparison.

Well	Type	2nd Quarter, FY02 (µg/L)[a]	2nd Quarter, FY03 (µg/L)[a]	Percent Change (±)[b]
299-W15-16	Monitoring	**900**	**2,550**	+183.3
299-W15-31A	Monitoring	*5,000*	*4,962*	-0.8
299-W15-32	Extraction	*3,250*	*2,400*	-26.2
299-W15-33	Extraction	*4,625*	*2,700*	-41.6
299-W15-34	Extraction	*5,800*	*5,500*	-5.2
299-W15-35	Extraction	*3,333*	*2,920*	-12.4
299-W15-36	Extraction	*1,300*	*1,000*	-23.1
299-W15-37	Monitoring	**680**	**73**	-89.3
299-W15-40	Monitoring	**3,400**	**2,300**	-32.3
299-W15-41	Monitoring	**1,400**	**1,300**	-7.1
299-W15-42	Monitoring	**1,750**	**1,200**	-25.7
299-W18-21	Monitoring	**20**	**14**	-30.0
299-W18-30	Monitoring	**150**	**120**	-20.0

[a] Concentrations in *italics* are by field analytical methods. Concentrations in bold are laboratory analytical methods.
[b] (2002 - 2003)/2002.

Flat or downward trends in contaminant concentrations are standard for most wells around the baseline plume. The seeming increase at well 299-W15-16 is misleading in that it is the result of comparing the lowest value (900 µg/L) ever reported at this well against a more routine value

from a long-term declining trend in concentrations. Although not reflected in the table above, the trend at well 299-W15-34 has actually shown a slight increase in carbon tetrachloride concentrations for FY03 and is the only well with an increase.

A comparison of data from wells north of the baseline plume with data from wells around the plume is less consistent. In the last 2 years, wells north of the extraction wells and west of the 241-TX/TY Tank Farm fence line (wells 299-W10-5, 299-W15-40, 299-W15-43, 299-W15-44, and 299-W15-765) have repeatedly yielded carbon tetrachloride concentrations greater than 2,000 µg/L. Figure 3-9 represents the broader, FY03 >2,000 µg/L carbon tetrachloride plume depicted in the *Hanford Site Groundwater Annual Report for Fiscal Year 2003* (PNNL 2004), and as superimposed on the 200-ZP-1 base map (Figure 3-1). Differences between plume configurations in Figures 3-8 and 3-9 result from the respective data sets used in contouring. Figure 3-9 used averaged laboratory values for the year to plot concentrations at a well. The extraction well capture zone extends far enough to the north and west to capture the original 1996 baseline plume. The data suggest that either a second source of carbon tetrachloride is active north of the current extraction well layout or that well data were too sparse in 1996 to detect the plume. Well data indicate carbon tetrachloride concentrations declined below 2,000 µg/L at well 299-W10-4 before November 1993 and >2,000 µg/L concentrations at well 299-W10-20 in September 1996.

3.4.2 Secondary Contaminants

Chloroform and TCE are the two secondary contaminants of concern at the 200-ZP-1 pump-and-treat system. Technetium-99 is also tracked at wells located between the injection and extraction wells as a means of monitoring movement of treated water through the aquifer. As shown in Figure 3-10, chloroform is not present at concentrations above the DWS of 80 µg/L, whereas TCE is present in some wells above the DWS of 5 µg/L (Figure 3-11). A 10 µg/L TCE plume is depicted around extraction wells 299-W15-34 and 299-W15-35 and extends north along the 241-TX/TY Tank Farm's west fence line. The 5 µg/L chloroform contour takes in all of the extraction wells, except for well 299-W15-33.

The following table compares results of chloroform concentrations from FY02 to FY03 at monitoring and extraction wells around the plume using data obtained with similar analytical techniques:

Well	Well Type	2nd Quarter, FY02 (µg/L)[a]	2nd Quarter, FY03 (µg/L)[a]	Percent Change (±)[b]
299-W15-16	Monitoring	**9.6**	**11.5**	+19.8
299-W15-31A	Monitoring	*49*	*30*	-38.8
299-W15-32	Extraction	*20*	*21*	+5.0
299-W15-33	Extraction	*17.5*	*11.5*	-34.2
299-W15-34	Extraction	*22.3*	*25*	+12.1
299-W15-35	Extraction	*16.3*	*16.8*	+0.3
299-W15-36	Extraction	*20.3*	*17*	-13.3
299-W15-37	Monitoring	**17**	**11**	-35.3
299-W15-40	Monitoring	**13**	**10**	-23.1
299-W15-41	Monitoring	**6.6**	**7.4**	+12.1
299-W15-42	Monitoring	**33.5**	**15**	-95.5
299-W18-30	Monitoring	**11**	**11**	0.0

[a] Concentrations in *italics* are by field analysis methods. Concentrations in bold are laboratory analysis methods.
[b] (2002 - 2003)/2002.

For TCE, the table below presents comparable values for FY02 and FY03:

Well	Well Type	2nd Quarter, FY02 (µg/L)[a]	2nd Quarter, FY03 (µg/L)[a]	Percent Change (±)[b]
299-W15-16	Monitoring	**1.6**	**2.1**	+31.3
299-W15-31A	Monitoring	*4.6*	*4.0*	-13.0
299-W15-32	Extraction	*3.9*	*4.1*	+5.1
299-W15-34	Extraction	*10.6*	*10*	-6.0
299-W15-35	Extraction	*8.8*	*9.1*	+3.4
299-W15-36	Extraction	*3.1*	*2.5*	-19.4
299-W15-37	Monitoring	**2.2**	**0.4**	-81.8
299-W15-40	Monitoring	**16**	**12**	-25.0
299-W15-41	Monitoring	**6.2**	**7.2**	+16.1

[a] Concentrations in *italics* are by field analysis methods. Concentrations in bold are laboratory analysis methods.
[b] (2002 - 2003)/2002.

The results for chloroform and TCE are more mixed than for carbon tetrachloride. As noted in Section 3.4, concentrations of these two contaminants increased at most extraction wells, although this table shows near-equal numbers of wells increasing versus decreasing.

3.5 AQUIFER RESPONSE

Aquifer response is important in assessing the effectiveness of the pump-and-treat system. Water-level measurements provide the basis for assessing the control pumping exerts over the flow around the plumes. Coupled with the knowledge of aquifer properties, the pumping system's capture zone can be predicted.

3.5.1 Hydraulic Monitoring

Groundwater flow in the 200-ZP-1 OU is generally from the southwest to the northeast with a hydraulic gradient of 0.001 m/m (Figure 3-12). The regional flow is generally more west-southwest to east-northeast across this portion of the 200 West Area, but the effects of injection and extraction are locally creating a more northeasterly flow. The impacts of pumping on the monitoring well water levels are observed at several locations.

Groundwater-elevation data collected during FY03 at locations away from the 200-ZP-1 extraction wells but within the monitoring well network indicate that the groundwater surface declined at an average of 0.36 m/yr (1.2 ft/yr). This is equal to the FY02 rate of decline, at 0.36 m/yr (1.2 ft/yr), but is significantly less than the 0.46 m/yr (1.5 ft/yr) reported for FY98. As at 200-UP-1, the decline is related to the 1985 cessation of discharges to the 216-U-10 Pond and a Sitewide halt to disposal of low-level waste streams to the soil column in 1995. An estimated 23,000 L/day (6,076 gal/day) of waste liquids were discharged to the soil column at sanitary tile field 2607-Z (Figure 3-1) until 1999. Additional information regarding hydraulic monitoring is presented in Appendix C.

3.5.2 Numerical Modeling

The calculated capture zones, shown by the streamlines in Figure 3-13, indicate the "reach" of pumping by the individual extraction wells since startup of the Phase II treatment system in 1996. The modeling shows that the extraction wells are capturing contaminants in the baseline plume area. It also suggests that the system of pumping and injection wells is about half way to establishing a recirculation zone, at least with respect to Phase II extraction wells 299-W15-33, 299-W15-34, and 299-W15-35. The streamlines indicate the range of influence for each well. The ends of the lines represent the approximate original location of water particles at the start of pumping on August 5, 1996 that reached the extraction wells by September 2003. Because there have been no significant changes to the 200-ZP-1 extraction system, the numerical modeling updates previous years' calculations and capture zones.

The FY98 annual report (DOE-RL 1999) contained a calculation of the length of time that the extraction wells could be shut down before high-concentration contaminants would move from the well to beyond the downgradient capture zone. It concluded that the pump may be shut down for up to 467 days before carbon tetrachloride at an extraction well would exit the capture zone. This calculation has not been repeated in FY03 and is regarded as valid, even with local declines in extraction rates. Due to the overlapping coverage of capture zones at wells 299-W15-33 and 299-W15-34, no adverse impact to plume containment was observed when the former well was off-line. A small but noticeable increase in carbon tetrachloride concentrations has been observed at well 299-W15-34 for FY03 compared to FY02. Additional information about groundwater modeling is presented in Appendix E.

3.6 CONCEPTUAL MODEL UPDATE

This section updates the conceptual model for carbon tetrachloride at the 200-ZP-1 groundwater pump-and-treat system, first presented in *Hydrogeologic Conceptual Model for the Carbon Tetrachloride and Uranium/Technetium-99 Plumes in the 200 West Area: 1994 Through 1999 Update* (BHI 1999). This document provides a detailed description of site geology, hydrogeology, waste characteristics, and waste site history, some of which are summarized below. With new data becoming available in FY04, significant improvements in the state of knowledge of carbon tetrachloride in the 200 West Area are expected from groundwater and vadose zone characterization work.

The vadose zone underlying the primary carbon tetrachloride source waste sites is approximately 65 m (213.3 ft) thick and consists predominantly of relatively permeable sand and gravel. A relatively less permeable interval, the Cold Creek unit, occurs at approximately 35 m (114.8 ft) in depth and consists of a carbonate-rich paleosol (caliche) overlain by silt and sand. Beneath the caliche, the Ringold Formation is divided into several units. An upper, finer-grained unit overlies Ringold Unit E, which is the water-bearing unit. The Ringold Unit E is a fluvial deposit consisting of coarse-grained, permeable sands, and gravels interbedded with finer-grained silty sands. Pumping rates at extraction wells are declining at 200-ZP-1 as the water table is descending through the coarser sands and gravels and into the finer silty sands. Pumping test data during well development indicate that the finer-grained units are producing lower volumes of water.

Carbon tetrachloride was discharged to the soil column at a number of waste sites south and east of the 234-5Z PFP. Estimated quantities of carbon tetrachloride discharged to the waste sites vary between 363,000 to 580,000 L (95,900 to 153,200 gal, or 577,000 to 922,000 kg) (BHI 1999). Carbon tetrachloride was discharged to the waste sites both in a dissolved, aqueous-phase form and also in mixtures with other organic liquids as DNAPL. Carbon tetrachloride subsequently migrated from the waste sites through the vadose zone and reached the groundwater beneath some of waste sites some years later. The carbon tetrachloride also migrated laterally within the vadose zone from the waste sites. Besides the regional groundwater flow, the 216-U-10 Pond is regarded as the major driver for carbon tetrachloride groundwater plume migration. The 216-T-4A Pond provided an early but more limited impact to the carbon tetrachloride migration, and other waste sites have had still smaller or shorter-lived effects on the plume movement.

Carbon tetrachloride can be present in the subsurface as vapor, dissolved in aqueous liquid, adsorbed on solid matrices, and as a separate DNAPL. The DNAPL, aqueous, and adsorbed phases tend to be associated with liquid contaminant pathways to the groundwater beneath and near the footprint of waste sites and, in some cases, from preferential flow (e.g., along or inside well casings). Concentrations of vapor-phase carbon tetrachloride have been found to be the highest near the disposal sites but are potentially more widely distributed in the vadose zone than the DNAPL, aqueous, and adsorbed phases. Carbon tetrachloride may volatize from the groundwater plume or, conversely, vapor-phase carbon tetrachloride may dissolve in groundwater, depending on the concentration differential. The rate and degree of exchange are described in part by the Henry's equilibrium constant.

Although a separate organic phase has not been directly observed in the vadose zone, the presence of carbon tetrachloride DNAPL has been inferred in the vicinity of the 216-Z-9 Trench at locations where relatively high soil vapor concentrations have been observed. (Soil that is

saturated with liquid carbon tetrachloride will have an associated equilibrium soil vapor concentration of 120,000 parts per million by volume [ppmv] at 20°C [68°F] [DOE-RL 1991]. Carbon tetrachloride mixed with other organics will have lower equilibrium soil vapor concentrations.) The high vapor concentration (>10,000 ppmv) observed in a soil vapor sample collected at the capillary fringe near the 216-Z-9 Trench site before soil vapor extraction remediation suggests that DNAPL may have reached the aquifer at this location.

3.6.1 Plume Extension

Perhaps the most significant change at the 200-ZP-1 OU is the detection of a 2,000 µg/L plume north of extraction wells 299-W15-33 and 299-W15-34 (see Figure 3-9). This plume is either an extension of the 1996 baseline carbon tetrachloride plume previously undetected as a result of inadequate well control or is a new secondary plume north of the 1996 baseline resulting from new sources of groundwater contamination. The 1996 carbon tetrachloride plume was based on sampling results at wells across the 200 West Area and was used to guide the pump-and-treat system design. Over the last 2 to 3 years, several new wells north of the pump-and-treat system (i.e., wells 299-W15-765, 299-W15-40, 299-W15-43, and 299-W15-44) have demonstrated sporadic to continuing carbon tetrachloride concentrations exceeding 2,000 µg/L. This complements data from older wells, 299-W10-4 and 299-W10-5, which exceeded the RAO either before or after the baseline plume data set.

If a second source of contamination is the cause, the most logical upgradient source for this plume would be one of the 218-W Burial Grounds that lie to the west and which received waste from 234-5Z Plant. Vadose zone characterization was conducted in FY02 at the trenches within 218-W-4C Burial Ground as part of the 200-PW-1 OU remedial investigation (FH 2004b). Trench ventilation risers were sampled at a number of locations, and elevated carbon tetrachloride vapor concentrations were encountered. Soil vapor sampling in the vadose zone adjacent to the trench detected low carbon tetrachloride concentrations. The 200-PW-1 OU will continue to investigate this and other burial grounds for carbon tetrachloride sources in FY04.

The leading edge of the 5 µg/L carbon tetrachloride groundwater plume has passed to the northeast of well 699-48-71. This well is located 360 m (1,180 ft) directly north of the northeast corner of the 200 West Area fence line and has been used to mark the advance of the 5 µg/L plume contour. Carbon tetrachloride concentrations rose from 1.8 µg/L in January 2000, to 7.4 µg/L in January 2002, and to 13.0 µg/L in July 2003. Other wells in the northeast corner of the 200 West Area also have reported increasing concentrations of carbon tetrachloride in the same timeframe.

3.6.2 Depth of Contaminants in Aquifer

As noted in *Hydrogeologic Conceptual Model for the Carbon Tetrachloride and Uranium/Technetium Plumes in the 200 West Area: 1994 Through 1999 Update* (BHI 1999), carbon tetrachloride has been observed at significant depths below the groundwater table for wells within and near the baseline plume. This condition may be the result of downward movement of the DNAPL or contaminant migration along or inside old well casings. Several monitoring wells have been drilled around the plume within the last several years, and groundwater in the boreholes was sampled to establish a vertical distribution of contaminants.

Well 299-W15-43 demonstrated a deep zone of carbon tetrachloride concentrations. This well is located approximately 270 m (885.9 ft) northwest of well 299-W15-34 and 200 m (656.2 ft) west of the 241-TX/TY Tank Farm fence line. The first carbon tetrachloride result greater than the 2,000 µg/L RAO (at 2,700 µg/L) was encountered at a depth of 8.3 m (27 ft) below the water table. The maximum concentration encountered (3,300 µg/L) was at 15 m (49 ft) below the groundwater table. The last greater-than-RAO concentration (2,900 µg/L) was at 21 m (75 ft) below the water table. A sample taken at 27.2 m (89 ft) below the water table reported a carbon tetrachloride concentration of 1,700 µg/L. At this borehole, the Ringold Unit E aquifer is largely a silty, sandy gravel changing to a gravelly sand at 105.8 m (347 ft) bgs, or 35.4 m (116.3 ft) below the water table. The concentration of carbon tetrachloride at this depth was 800 µg/L.

Carbon tetrachloride has been reported at significant depths in other downgradient wells. Around the 241-T Tank Farm, carbon tetrachloride was encountered in well 299-W10-24 at a depth of 28.2 m (92.5 ft) below the groundwater table at concentrations of 1,600 µg/L. At well 299-W14-14, along the east fence line of the 241-TX/TY Tank Farms, a concentration of 920 µg/L was found at a depth of 35.9 m (118 ft) below the groundwater table.

Well 299-W15-42, located east of 234-5Z Plant, was drilled during the second quarter of FY02. The one carbon tetrachloride concentration exceeding the 2,000 µg/L RAO (2,800 µg/L) was encountered at 6 m (19.7 ft) below the top of the groundwater table, supporting the contention that carbon tetrachloride is located primarily within the upper 10 m (32.8 ft) of the aquifer. Samples taken a month later at the same depth did not exceed 1,800 µg/L.

High concentrations of chloroform (680 and 640 µg/L) were found at well 299-W15-42 between 9 and 17 m (30 and 55 ft) below the top of the groundwater table. The well is located near the northwest corner of the 2607-Z sanitary drain field, which ceased operations in 1999. Chloroform is a breakdown product of carbon tetrachloride but is also associated with sanitary waste systems, which may be another source for elevated concentrations of the contaminant.

3.6.3 Soil Vapor Remediation

Soil vapor extraction has been in use since 1991 under an interim remedial action to remove carbon tetrachloride from the vadose zone in the vicinity of the primary known carbon tetrachloride waste sites (i.e., 216-Z-1A tile field, 216-Z-9 Trench, 216-Z-18 Crib, and 216-Z-12 Crib) (BHI 2002, FH 2003b). Characterization activities associated with the interim action have focused on the known source area. Within this area, carbon tetrachloride has been found throughout the vadose zone, both within and beyond the boundaries of the known waste sites. The lateral extent of the dispersed vadose zone plume may extend as far as the associated carbon tetrachloride groundwater plume; however, limited data have been collected outside of the source zone area. Thus, the geometry of the entire carbon tetrachloride vadose zone plume is not well defined. Through FY03, the soil vapor remedial systems have extracted over 78,090 kg, or about 12% of the total mass disposed at the waste sites.

The existing soil and soil vapor sampling data provide a relative indication of the distribution of carbon tetrachloride in the vadose zone near the source zone area. The observed distribution of vapor concentrations in the subsurface separates the vadose zone into areas of high and low contamination and suggests that the Cold Creek unit is the horizon currently containing significant concentrations of carbon tetrachloride. The higher carbon tetrachloride concentrations in soil samples also are associated with the Cold Creek unit. Significant conclusions regarding the distribution of carbon tetrachloride are as follows:

- Laterally, the highest concentrations of carbon tetrachloride historically have been located in the vicinity of the 216-Z-9 Trench.
- Vertically, the highest concentrations are associated with the finer-grained, relatively less permeable units (the Hanford lower fine and Cold Creek units). If most of the residual carbon tetrachloride is sorbed in these units, it is likely that little or no continuing source is moving into the groundwater.

3.6.4 Groundwater Remediation

The area of highest carbon tetrachloride groundwater concentrations (i.e., >2,000 µg/L) appears to be located beneath the Z Plant (234-5Z and 231-Z) complex rather than directly under the known carbon tetrachloride waste sites. Alternate conceptual models that have been proposed to explain the apparent displacement of high groundwater concentrations from the known waste sites and include the following:

- Vertical migration in the vadose zone from unknown waste sites or unsuspected waste sites overlying the groundwater plume that are or were acting as active sources to groundwater
- Lateral migration in the vadose zone from known waste sites to areas overlying the groundwater plume that are or were acting as active sources to groundwater
- Lateral migration in the groundwater from known waste sites as a result of complex groundwater gradients and migration patterns driven by changing aquifer hydraulics.

To date, pump-and-treat system operations at 200-ZP-1 have recovered more than 7,668 kg of carbon tetrachloride from the groundwater. The baseline plume, defined by the >2,000 µg/L contour, is centered beneath the 234-5Z PFP and 231-Z Building, both of which used carbon tetrachloride in various processes. With pumping and injection of treated groundwater, the plume has migrated northeast to the Phase II extraction wells (299-W15-33, 299-W15-34, and 299-W15-35).

Significant changes to the area and location of the >4,000 µg/L plume have been observed since Phase II startup. The contour of this plume is currently defined only at two wells (299-W15-34 and 299-W15-1). The FY03 2,000 µg/L carbon tetrachloride contour has also shifted to the north.

A calculation was performed to determine the mass of carbon tetrachloride removed from the baseline plume by comparing changes in area of the 2,000 and 4,000 µg/L plumes between 1996 and 2003 (Figure 3-8). Both the 1996 baseline and the FY03 2,000 and 4,000 µg/L plume contours were digitized and areas were calculated for each. A 10-m (32.8-ft)-thick zone of carbon tetrachloride was assumed, along with two porosity values (10% and 30%). The mass within each plume contour was then calculated using the contour values. The table below presents the area, volume, and mass calculations for the 1996 and FY03 plumes:

Measure	1996	2003
Area within 4,000 µg/L contour (m^2)	75,527	32,590
Area within 2,000 µg/L contour (m^2)	243,016	223,942
Area of 2,000 µg/L contour (m^2) (i.e., 2,000 µg/L minus 4,000 µg/L contour area)	167,484	191,352
Volume of 4,000 µg/L contour with 10 m aquifer thickness for 10%/30% porosity (m^3)	75,527 / 226,581	32,590 / 97,770
Mass of carbon tetrachloride in 4,000 µg/L contour for 10%/30% porosity (kg)	302.1 / 906.3	130.4 / 391.2
Volume of 2,000 µg/L contour with 10 m aquifer thickness for 10%/ 30% porosity (m^3)	167,484 / 502,452	191,352 / 574,056
Mass of carbon tetrachloride in 2,000 µg/L contour for 10%/30% porosity (kg)	335 / 1,005	382.7 / 1,148.1
Total mass of carbon tetrachloride for 10%/30% porosity (kg)	637.1 / 1,911.3	513.1 / 1,539.3
Difference between 1996 baseline and FY03 calculated masses (for 10% and 30% porosity) (in kg)	**124 / 372**	

The calculated mass of 372 kg removed from the upper 10 m (32.8 ft) of the aquifer is less than 5% of the 7,668 kg of carbon tetrachloride removed by the groundwater pump-and-treat system. The combined mass removed by groundwater pump-and-treat system and the soil vapor extraction system is 85,760 kg of carbon tetrachloride. This is 9% to 15% of the 577,000 to 922,000 kg of carbon tetrachloride reportedly disposed to the soil column. The discrepancy between the mass reportedly discharged to the soil column and removed by vadose zone and groundwater treatment systems is the subject of ongoing DOE and 200-PW-1 OU characterization activities.

3.6.5 Particle-Tracking Modeling

Particle-tracking modeling was performed in FY02 (DOE-RL 2003a) for carbon tetrachloride using groundwater elevation data from Pacific Northwest National Laboratory's (PNNL's) Sitewide model. The modeling was designed to help understand the distribution of carbon tetrachloride in the groundwater. The goal of the study was to relate current plume locations beneath the 234-5Z Facility with discharges to waste sites.

The model created yearly updates of groundwater table configuration, flow velocity, and flow direction to portray yearly contaminant movement. This information was then assembled into an animation sequence. Small retardation values were built-in for both forward and backward particle-tracking runs to determine if the carbon tetrachloride plumes more accurately tracked actual plume movements. Other models were run to simulate continuous sources at the waste sites.

The model runs start in 1955 with carbon tetrachloride discharges into the 216-Z-9 Trench, which reached groundwater in 8 years. Based on historical records, carbon tetrachloride was then added at the other sites as they became active. In running the model forward in time from 1955 to 2002, a carbon tetrachloride plume extended east-northeast from the 216-Z-9 Trench. The carbon tetrachloride plume at the 216-Z-1A and 216-Z-18 Cribs slowly moved north

beneath the 234-5Z PFP, corresponding to the FY02 plume distribution. Running the model backward in time, beginning with FY02's 2,000 and 4,000 µg/L carbon tetrachloride contours, produced a backtracking beneath 216-Z-1A and 216-Z-18, toward the 216-U-10 Pond.

Particle tracking using a refined mesh from PNNL's Sitewide model will be performed in FY04. It is expected that the new modeling will better depict the waste site inputs and groundwater elevation control data in a more spatially realistic and accurate manner and will also provide a better sense of carbon tetrachloride movement in the groundwater.

3.7 QUALITY ASSURANCE/QUALITY CONTROL

The quality control check for the 200-ZP-1 OU was performed using field and offsite replicate and field/offsite laboratory splits testing for carbon tetrachloride, chloroform, and TCE. All results are from wells associated with the pump-and-treat system. Highlights of the quality control data are presented in the following table, and more detailed information and data sets are presented in Appendix G. Monitoring wells close to the RAO plume were sampled semi-annually, and wells near the plume periphery were sampled annually.

Type of Quality Control Sample	Number of Pairs	Number of Pairs <20% RPD	Percentage <20% RPD
Field replicates, carbon tetrachloride	14	14	100%
Field replicates, chloroform	14	14	100%
Filed replicates, TCE	14	14	100%
Offsite laboratory replicates, carbon tetrachloride	9	8	89%
Offsite laboratory replicates, chloroform	9	9	100%
Offsite laboratory replicates, TCE	9	9	100%
Field/offsite laboratory splits, carbon tetrachloride	8	2	25%
Field/offsite laboratory splits, chloroform	10	10	100%
Field/offsite laboratory splits, TCE	10	5	50%

The EPA function guidelines for field replicates is ±20% (EPA 1988); there are no functional guidelines for splits results. For replicates, 68 of the 69 samples were below the ±20% standard.

For the six carbon tetrachloride field/offsite laboratory splits exceeding the 20% RPD, the results appear similar to a pattern observed in the FY02 report (DOE-RL 2003a). For five of the six pairs with RPDs of 23.3% to 58.2%, the offsite laboratory results are significantly lower than the field results. This is attributed to the longer holding times before the samples were analyzed, five to eleven days for the five FY03 samples (see Appendix G). In no case was the holding-time limit exceeded; however, a general correlation between longer holding times and lower carbon tetrachloride results is suspected.

3.8 CONCLUSIONS

Measurable progress was made this year toward meeting the specific interim remedial measures. The RAOs for the 200-ZP-1 OU pump-and-treat operation in FY03 were as follows:

- ***RAO #1: Prevent further movement of contaminants from the highest concentration area of the baseline plume.***

  Results: The pump-and-treat system continues to capture the high-concentration levels of carbon tetrachloride (>2,000 to 3,000 µg/L) at the extraction wells. The modeling analysis shows that even with mildly reduced extraction rates, groundwater is still being captured by the extraction wells. The phenomenon of treated water pushing contaminated water toward the extraction wells is illustrated at several wells where technetium-99 concentrations are increasing, indicating the arrival of treated injected water. Downgradient well 299-W15-39, located outside the zone of influence of adjacent extraction wells, has consistently been below the 2,000 µg/L RAO since the start of monitoring in July 1996 at the beginning of Phase II operations. Only one value, 2,500 µg/L in January 2000, exceeded the RAO and concentrations have since declined to less than 1,000 µg/L.

  Based on current extraction and monitoring well data, the 4,000 µg/L carbon tetrachloride contour has decreased significantly in size. While this may be due to downtime and lower extraction rates at well 299-W15-33, only two wells currently average over 4, 000 µg/L per annum.

  At well 299-W15-36, concentrations of carbon tetrachloride are less than 55% of the >2,000 mg/L RAO. The well should be shut down if the production wells can pump enough water to reach an extraction rate of 567.8 L/min (150 gpm), as specified in the interim action ROD (EPA et al. 1995).

- ***RAO #2: Reduce contamination in the areas of highest concentration of carbon tetrachloride.***

  Results: The treatment system removed 819.3 kg of carbon tetrachloride in FY03 in 253,600,000 L (6,695,040 gal) of groundwater. Since the startup of operations, over 2,149,800,000 L (576,547,200 gal) of water have been extracted and 7,668.3 kg of carbon tetrachloride have been removed.

  Concentrations of carbon tetrachloride continue to decrease. The average concentration for FY03 was 3,212 µg/L, as measured at the T-01 influent holding tank. Carbon tetrachloride concentrations at each extraction well were down from the FY02 averages, except at well 299-W15-34, which experienced a slight increase.

- ***RAO #3: Provide information that will lead to development of a final remedy that will be protective of human health and the environment.***

  Result: Where possible, data that help to refine the conceptual model for the carbon tetrachloride plume are collected during the course of characterization and remediation activities. Vertical profile samples and geologic data were collected during installation of new well 299-W15-43. A replacement extraction well at 299-W15-33 (i.e., 299-W15-45) was drilled and logged. In addition, two RCRA wells (299-W15-44 and 299-W15-765) were sampled for the first time for carbon tetrachloride. Sampling at well 299-W15-44 will continue for the foreseeable future. Carbon tetrachloride characterization activities

were also conducted in the vadose zone in FY03 for the 200-PW-1/PW-3/PW-6 source OUs. A new extraction well and a number of new monitoring wells will be drilled in the 200-ZP-1 Groundwater OU in FY04 and FY05.

3.9 RECOMMENDATIONS

The following recommendation is made to improve performance at the 200-ZP-1 pump-and-treat system:

- **Option of converting well 299-W15-36 from an extraction to a monitoring well.**

  Carbon tetrachloride concentrations have declined to below the >2,000 µg/L RAO at well 299-W15-36. Continued operation of this well may be pulling the 1,000 and 2,000 µg/L plume contours to the southeast, away from the main body of carbon tetrachloride contamination. The trend for well 299-W15-36 has been below 2,000 µg/L since FY99 (DOE-RL 2000) and averaged just below 1,100 µg/L for FY03. The current plume configuration (Figure 3-8) depicts the 1,000 µg/L contour extending to the southeast and around this well.

  This well has provided approximately 16% of the total water extracted at the 200-ZP-1 OU in FY03. To convert this well will require that increased production from the two new replacement extraction wells (299-W15-45 and 299-W15-47) be obtained to meet the 567.8 L/min (150 gpm) extraction goal. If well 299-W15-36 is converted to a monitoring well, it would be used to assess future plume changes and to detect carbon tetrachloride movement to the southeast.

  A quarterly sampling program should be instituted at this well for one year after shutdown. This will monitor for contaminant concentration changes with time and insure a timely restart of the pump if carbon tetrachloride concentrations above 2,000 µg/L are observed.

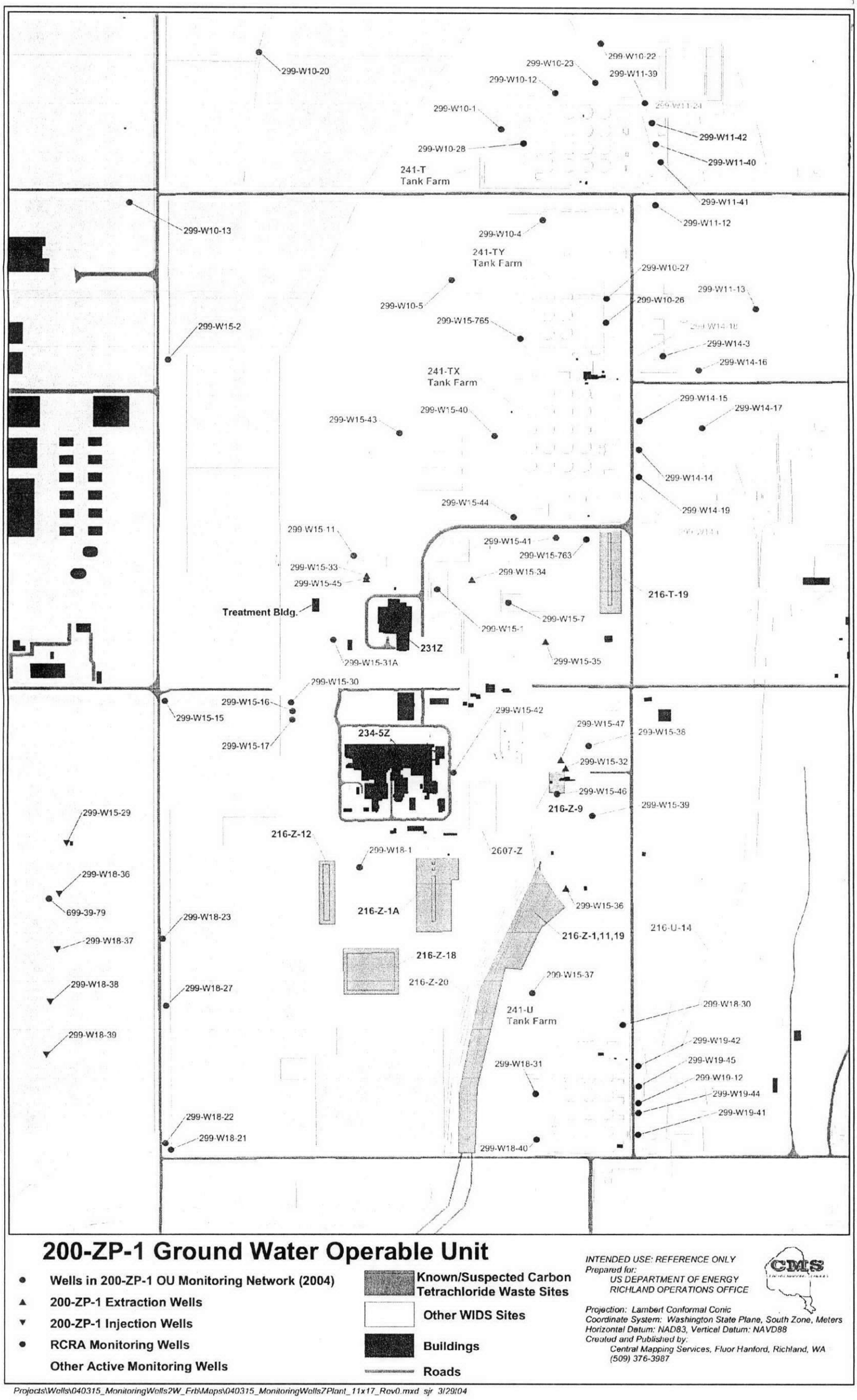

Figure 3-1. 200-ZP-1 Operable Unit Groundwater Well Network and Other Monitoring Wells.

200-ZP-1 Ground Water Operable Unit

- Wells in 200-ZP-1 OU Monitoring Network (2004)
- 200-ZP-1 Extraction Wells
- 200-ZP-1 Injection Wells
- RCRA Monitoring Wells
- Other Active Monitoring Wells

- Known/Suspected Carbon Tetrachloride Waste Sites
- Other WIDS Sites
- Buildings
- Roads

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Prepared for:
US DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE

Projection: Lambert Conformal Conic
Coordinate System: Washington State Plane, South Zone, Meters
Horizontal Datum: NAD83, Vertical Datum: NAVD88
Created and Published by:
Central Mapping Services, Fluor Hanford, Richland, WA
(509) 376-3987

Projects\Wells\040315_MonitoringWells2W_Frb\Maps\040315_MonitoringWells7Plant_11x17_Rev0.mxd sjr 3/29/04

Figure 3-2. 200-ZP-1 Operable Unit Interim Remedial Operation Phase III Pump-and-Treat Design Process Flow Diagram.

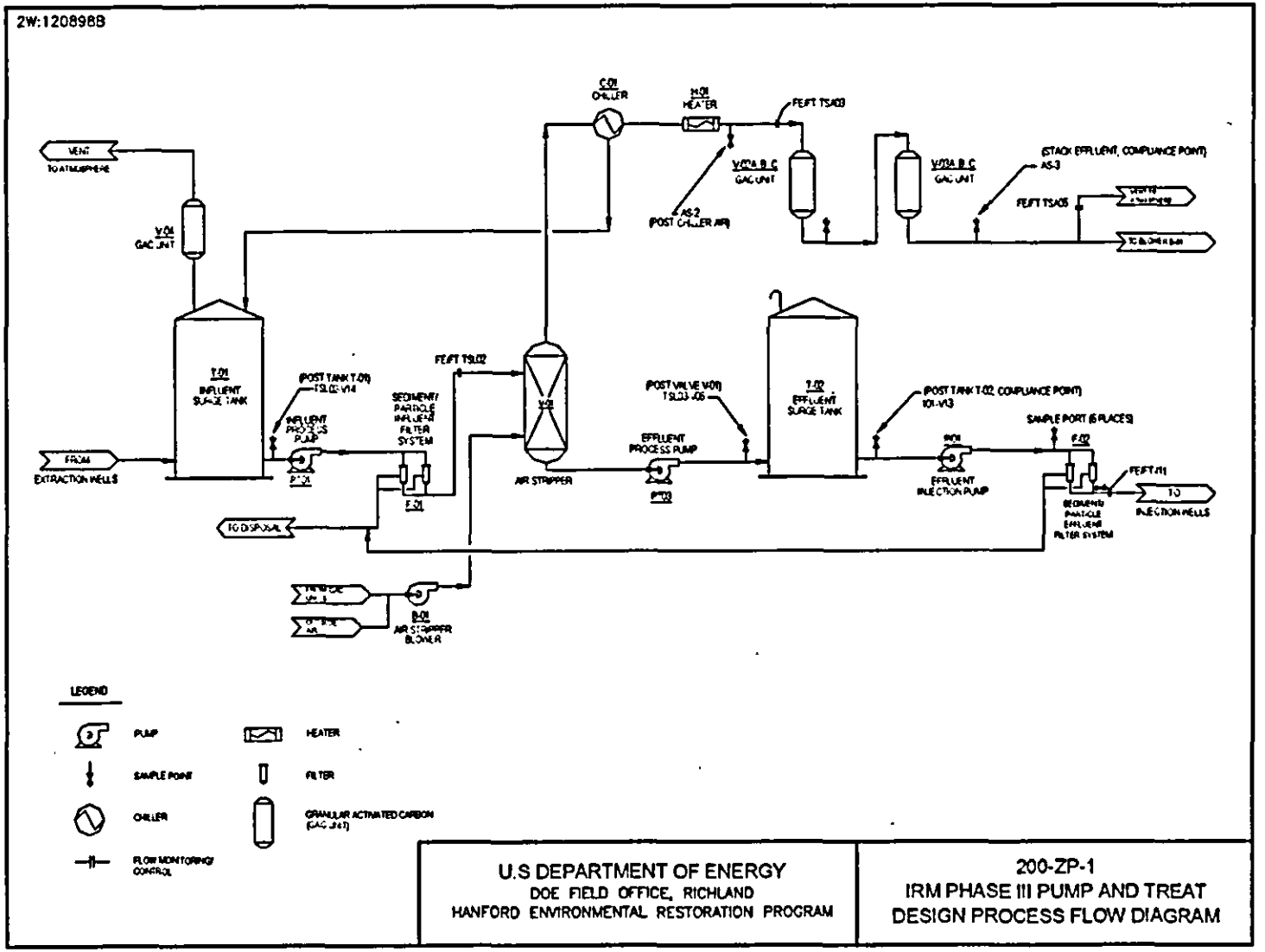
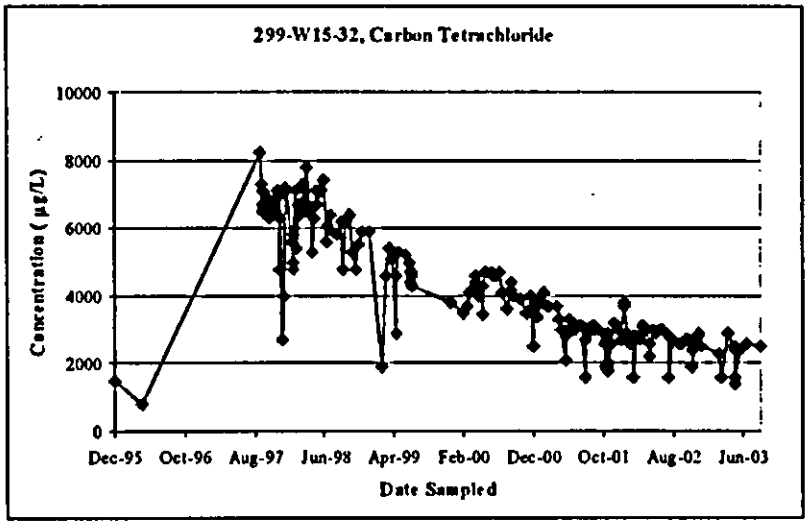
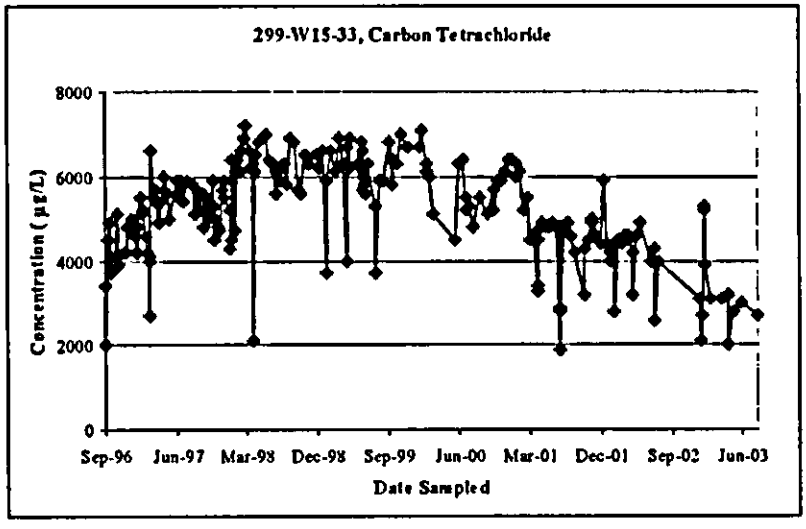


Figure 3-3. Carbon Tetrachloride Extraction Well Trend Plots. (2 sheets)





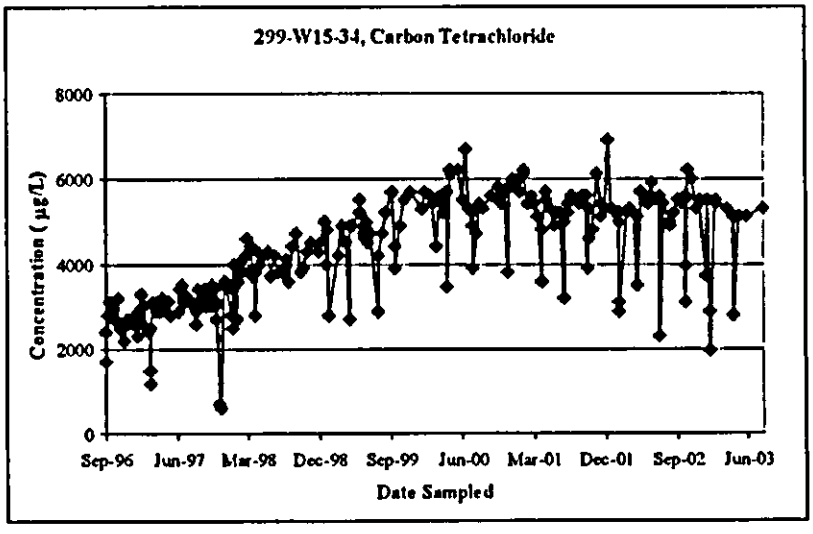
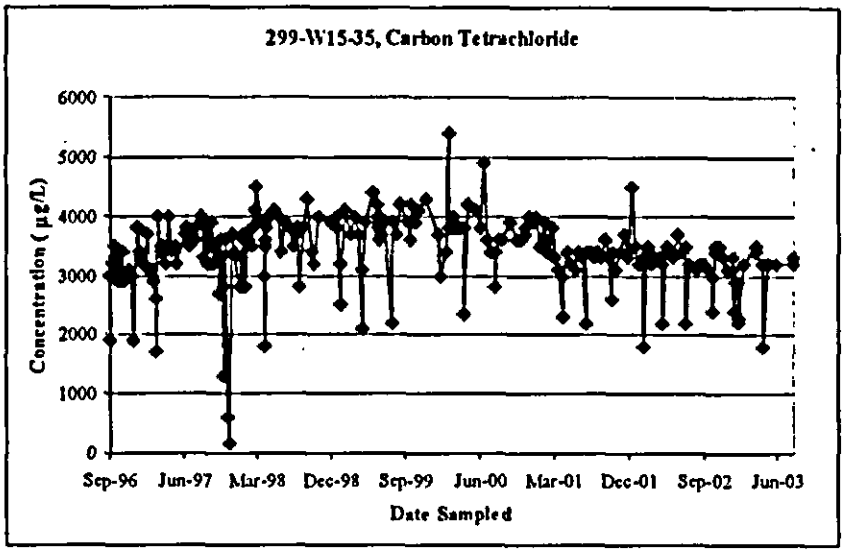


Figure 3-3. Carbon Tetrachloride Extraction Well Trend Plots. (2 sheets)



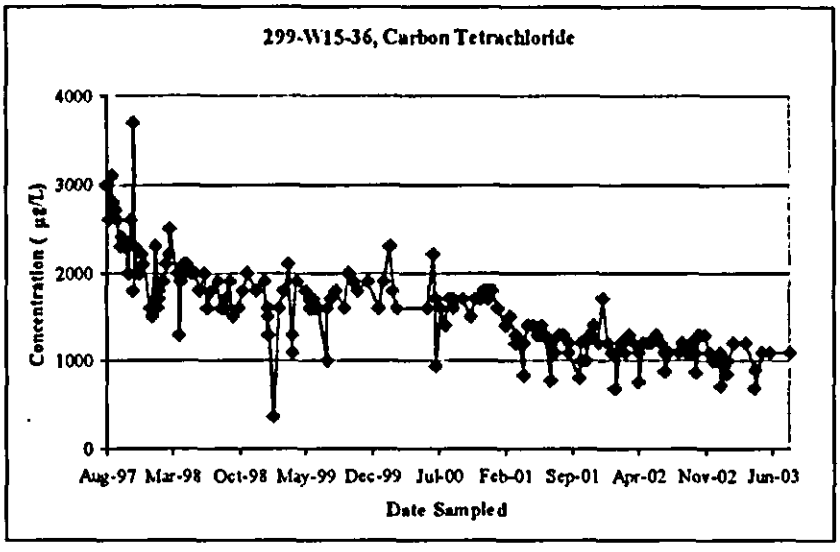
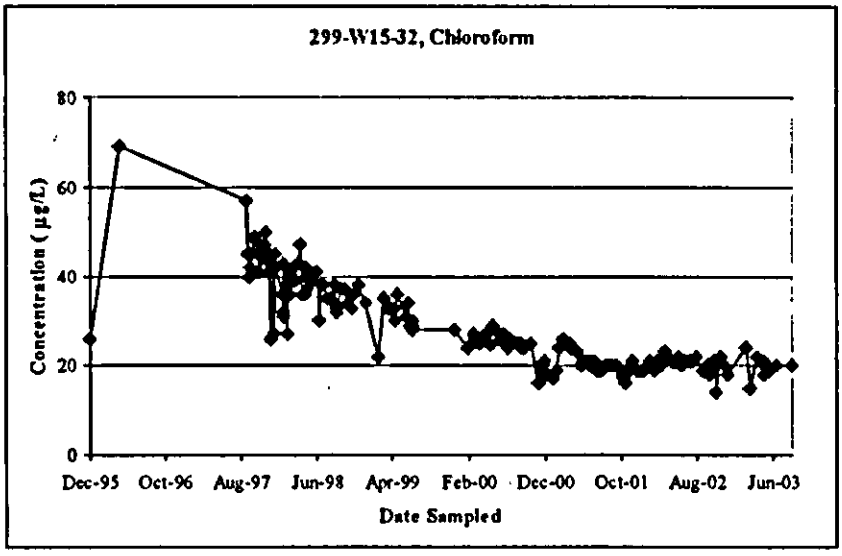
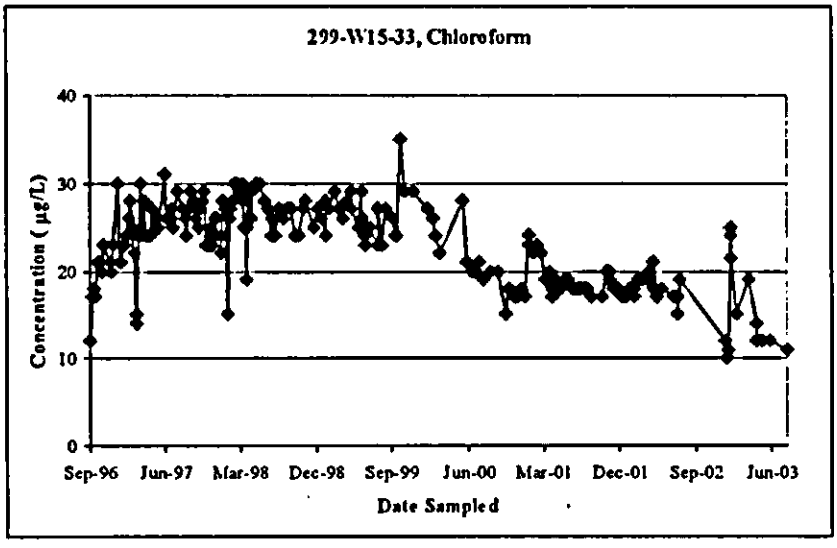


Figure 3-4. Chloroform Extraction Well Trend Plots. (2 sheets)





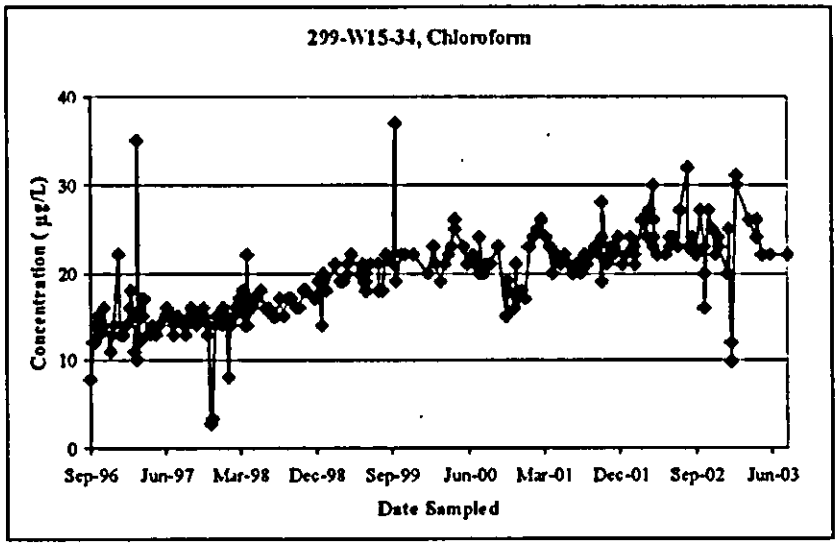
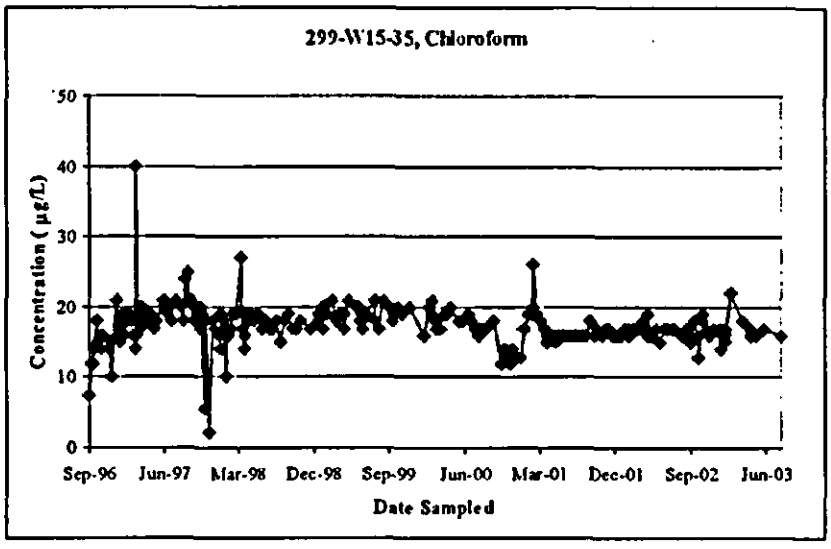


Figure 3-4. Chloroform Extraction Well Trend Plots. (2 sheets)



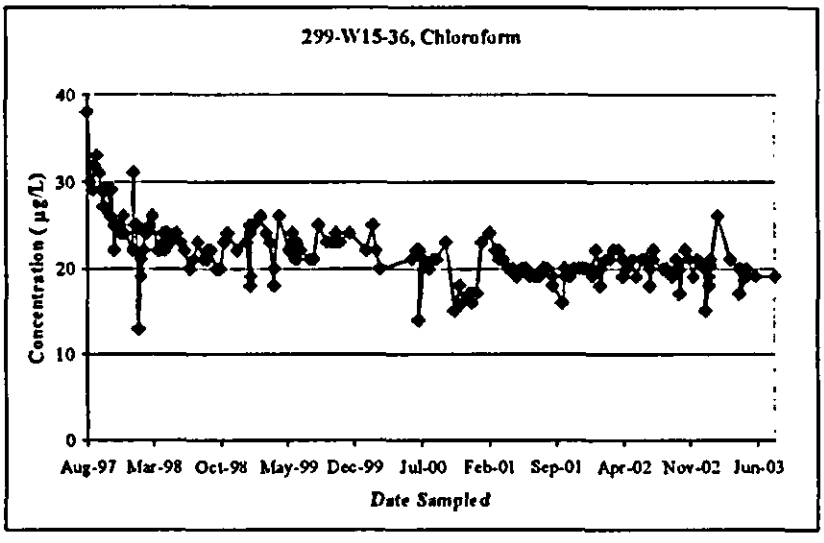
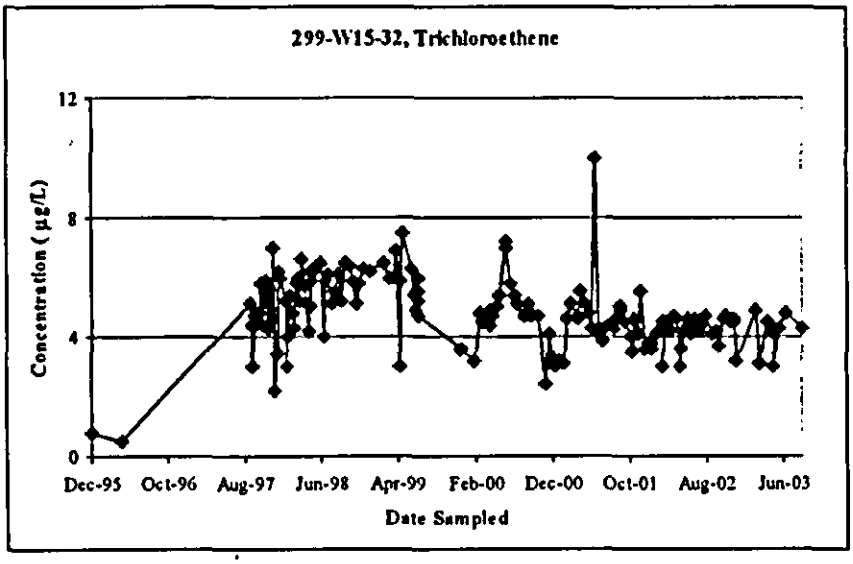
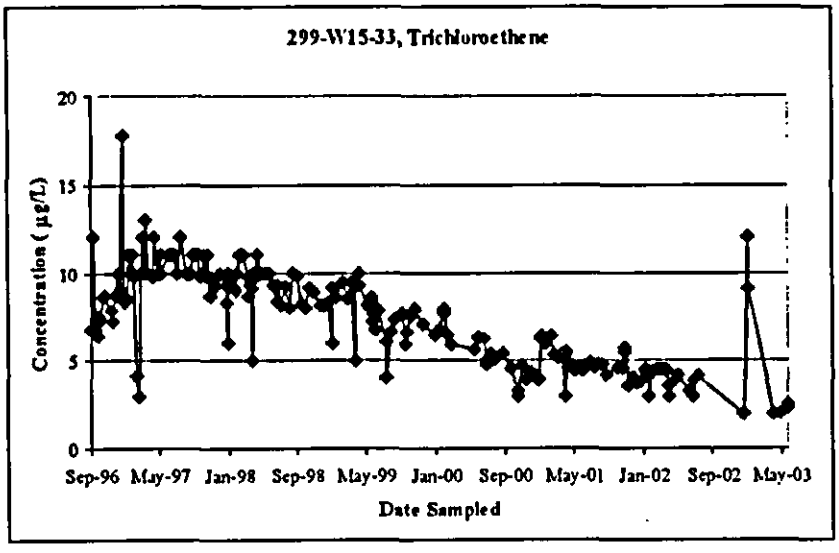


Figure 3-5. Trichloroethene Extraction Well Trend Plots. (2 sheets)





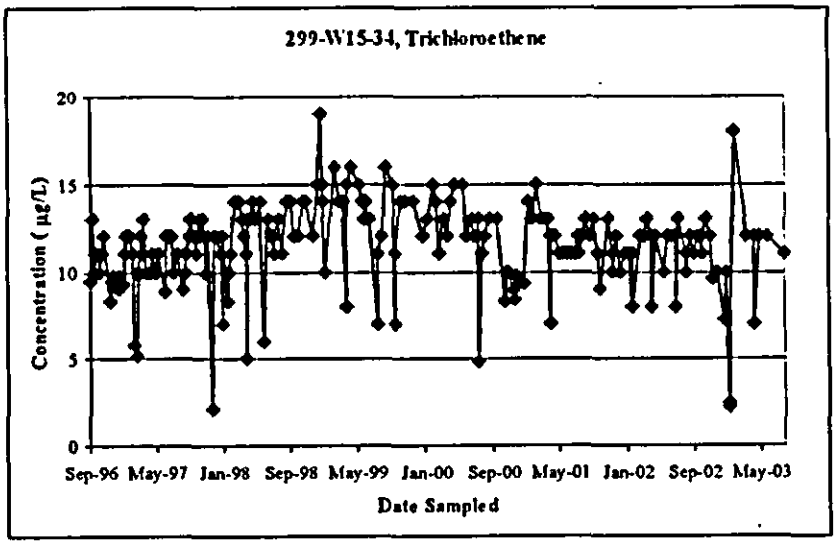
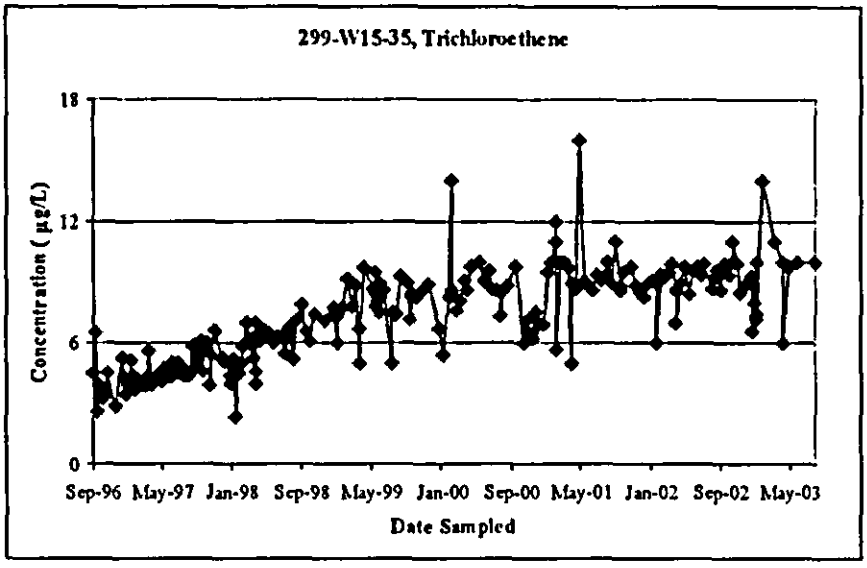


Figure 3-5. Trichloroethene Extraction Well Trend Plots. (2 sheets)



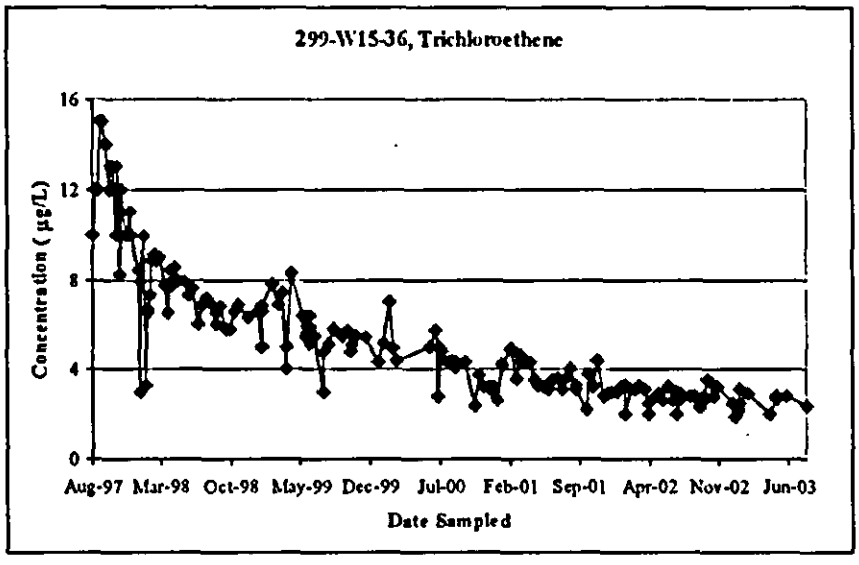
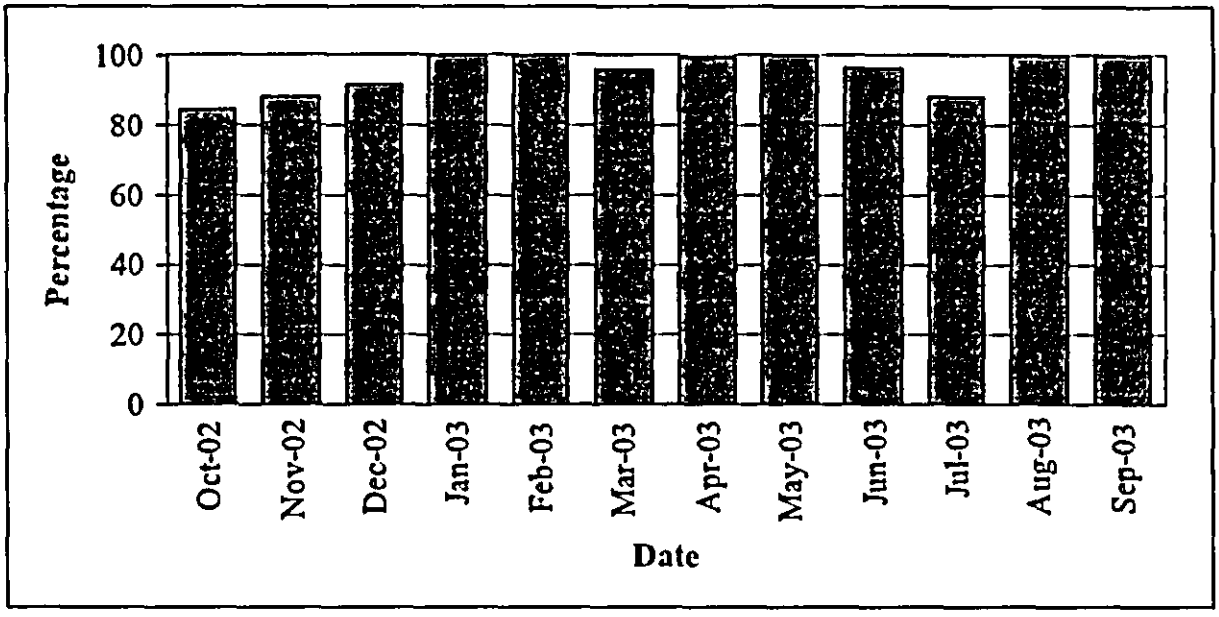


Figure 3-6. 200-ZP-1 Operable Unit Pump-and-Treat System Availability.



System availability:

Total hours in FY03 = 8,760 hours
Total time available during FY03 (total hours minus scheduled outages) = 8,510 hours
Total time on-line during FY03 (total hours minus all outages) = 8,342 hours
System on-line availability ({total time on-line/total hours} x 100) = 95.2%
Total system availability ({total time available/total hours} x 100) = 98.0%

Scheduled and unscheduled system outages:

10/07/02	Scheduled outage. System shut down for 46.5 hours for heater/chiller maintenance.
10/22 to 10/24/02	Scheduled outage. System shut down for 4 hours for heater/chiller repairs.
10/31/02	Scheduled outage. System shut down for 23 hours for heater/chiller repairs.
11/02 to 11/04/03	Unscheduled outage. System shut down 45.5 hours due to condensate build-up in piping, tripping off the leak detection system. No leak found.
11/04/02	Scheduled outage. System shut down for 24.5 hours for heater/chiller repair.
03/25 to 03/26/03	Scheduled outage. System shut down for 22 hours for maintenance on TSL02.
06/10 to 06/11/03	Scheduled outage. System shut down for 25.5 hours to replace isolation valve.
07/03 to 07/07/03	Unscheduled outage. System shut down 76.5 hours due to power outage.
07/15/03	Scheduled outage. System shut down for 5.5 hours for PT01 pump changeout.

Figure 3-7. 200-ZP-1 Operable Unit Carbon Tetrachloride Concentrations at Influent Tank T-01 and Effluent Tank T-02 (with Removal Efficiencies), Fiscal Year 2003.

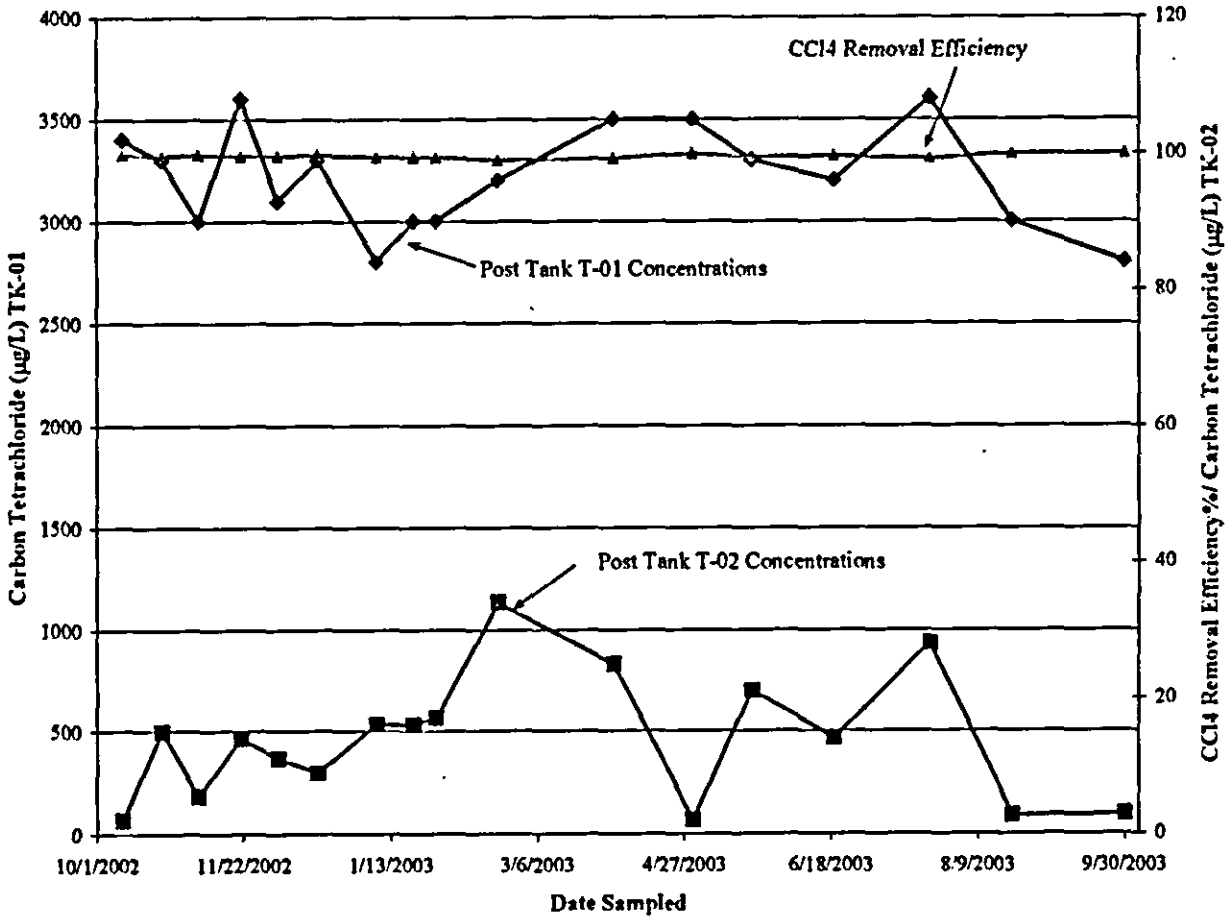


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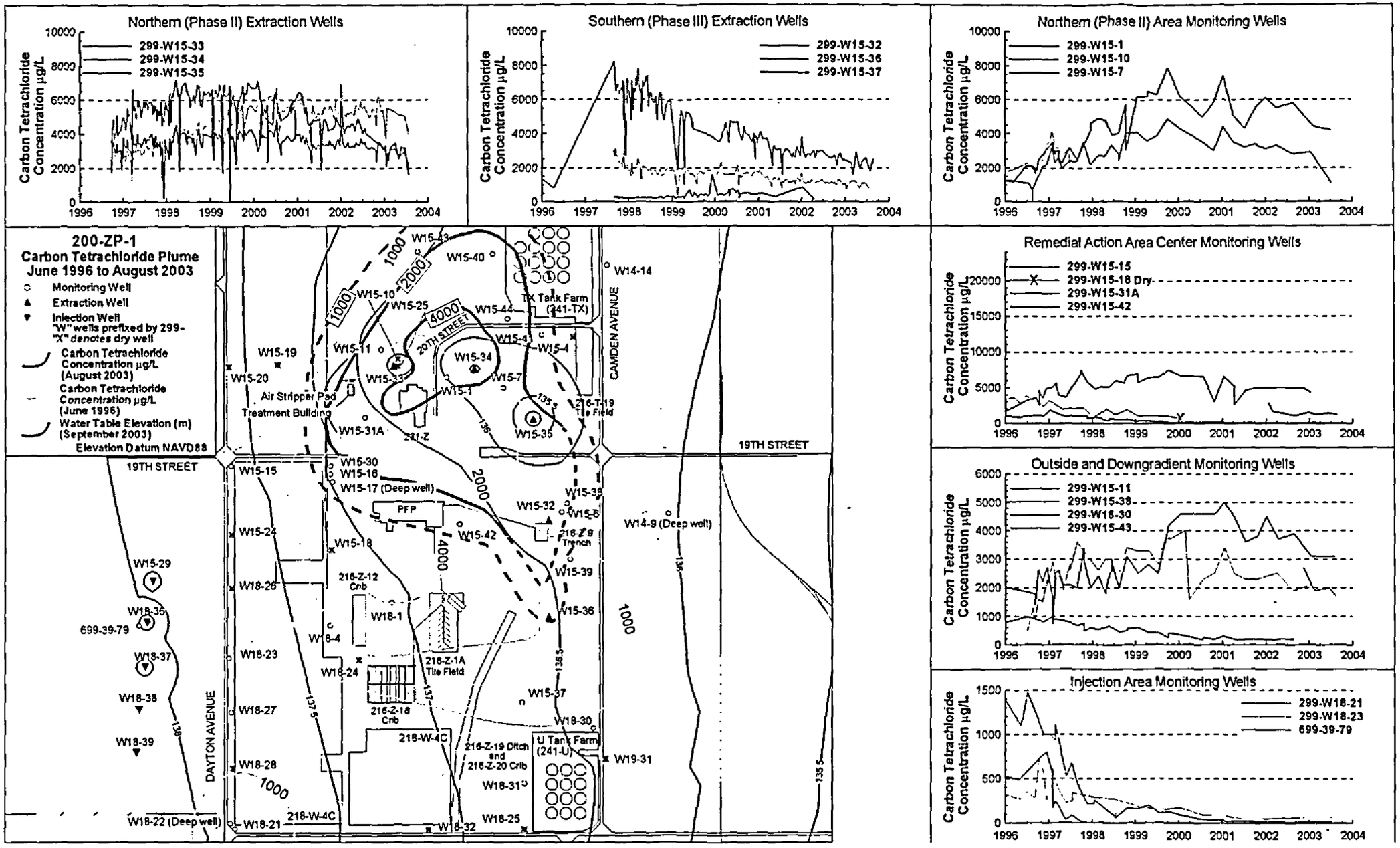
Figure 3-8. 200-ZP-1 Operable Unit Carbon Tetrachloride Contaminant Plume: Baseline June 1996 Versus August 2003.



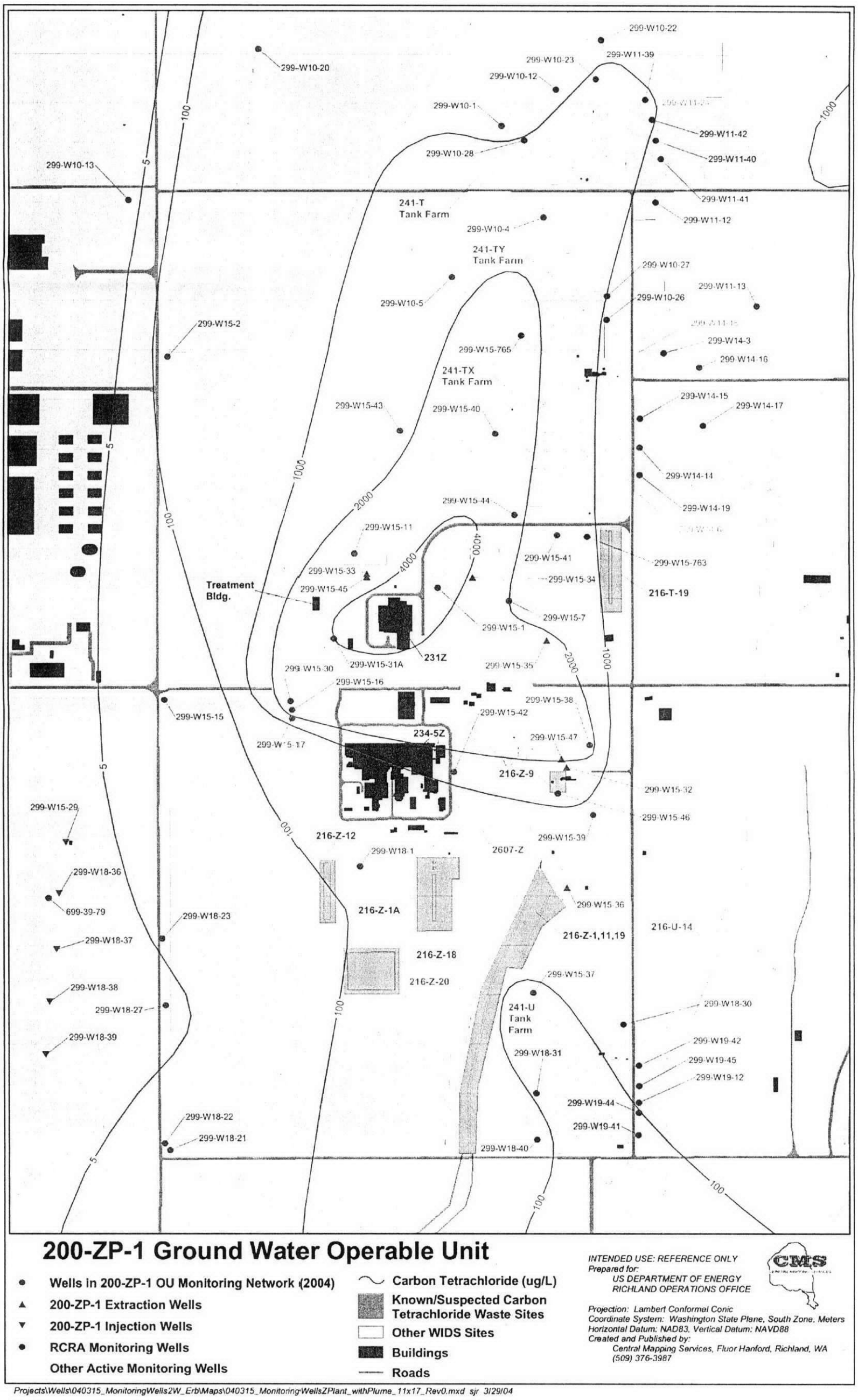


Figure 3-9. 200-ZP-1 Monitoring Wells, Z Plant with Plume.

Figure 3-10. 200-ZP-1 Operable Unit Chloroform Contaminant Plume, August 2003.

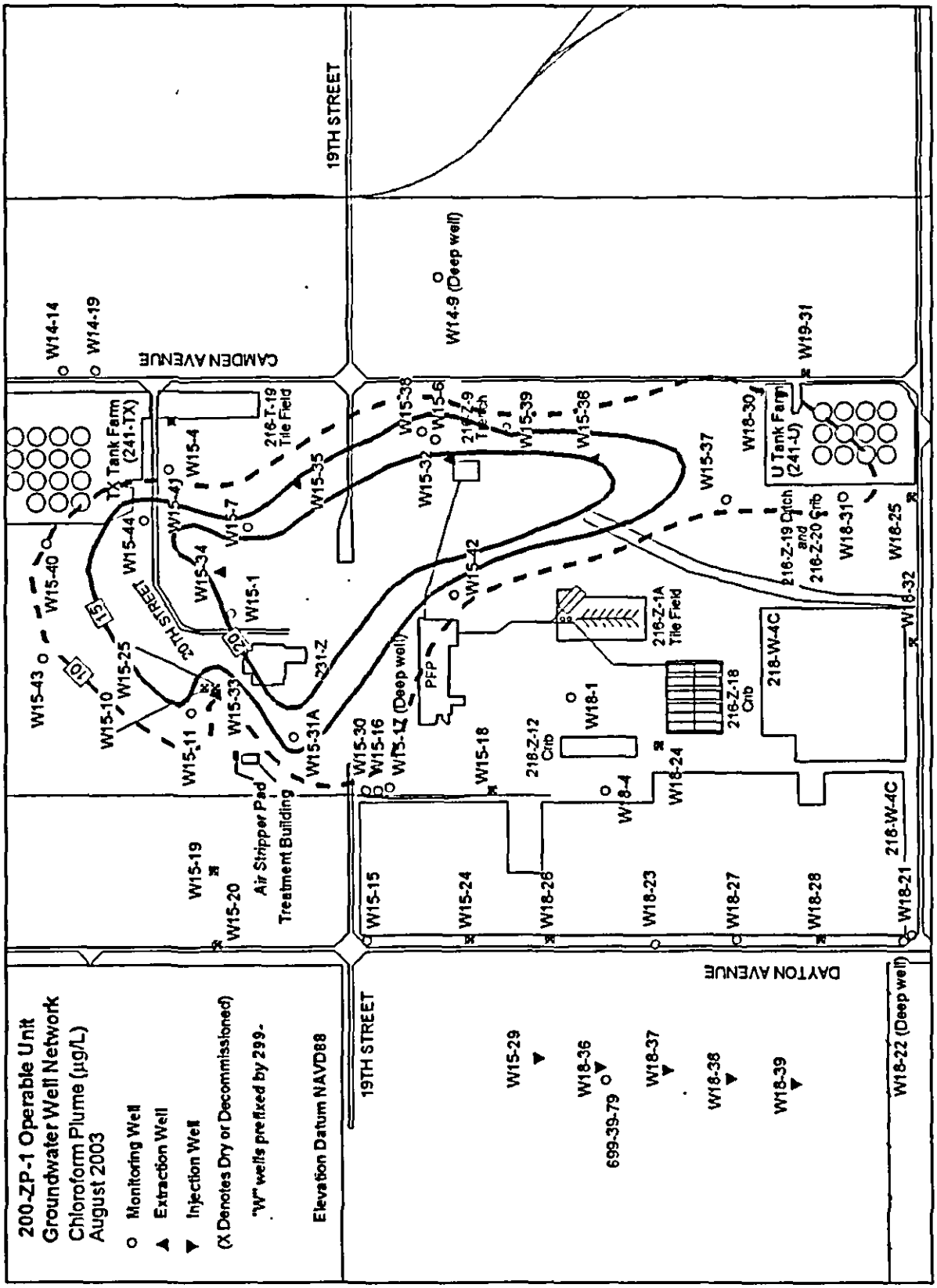


Figure 3-11. 200-ZP-1 Operable Unit Trichloroethene Contaminant Plume, August 2003.

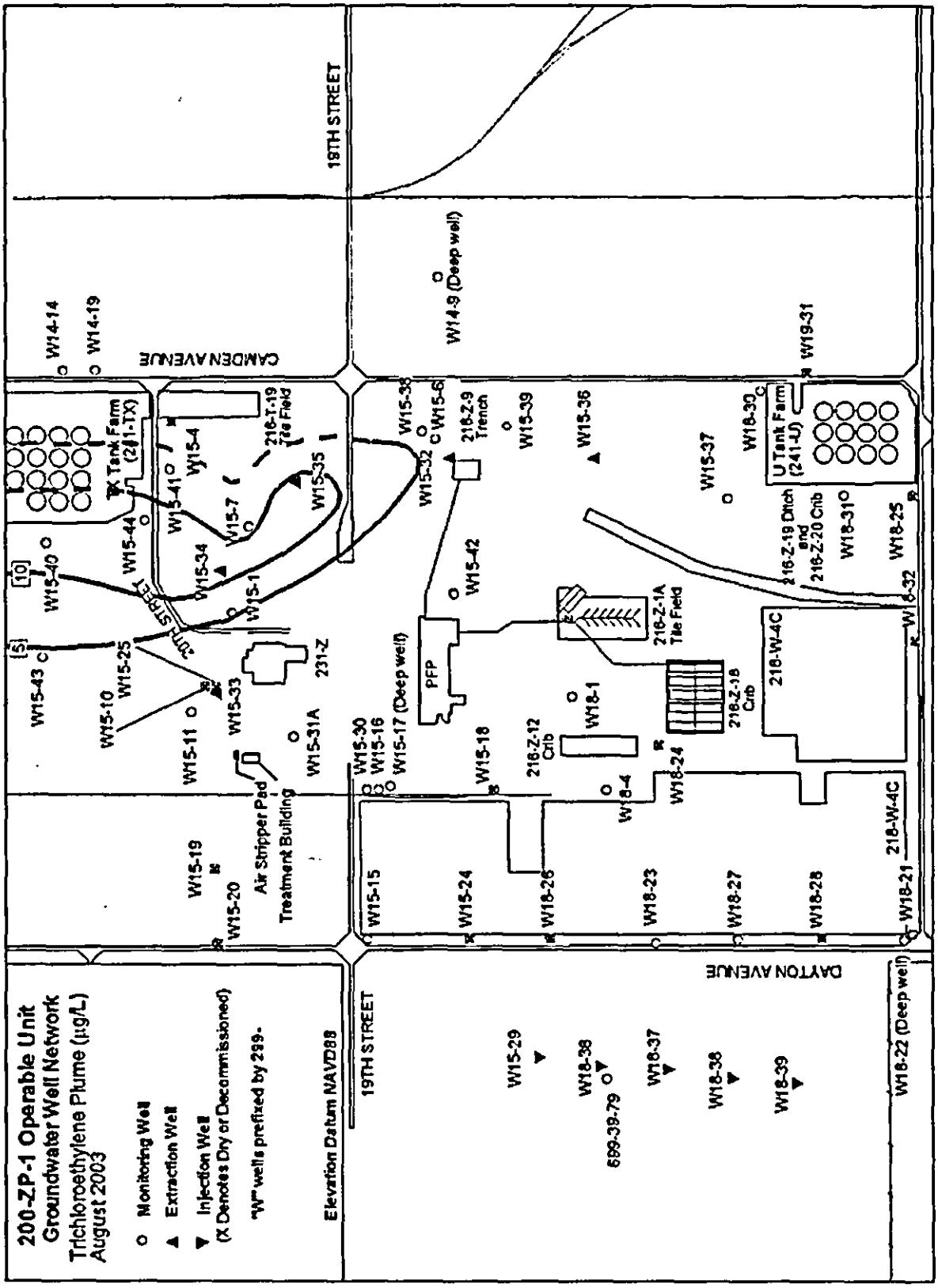


Figure 3-12. 200-ZP-1 Operable Unit Water Table Map: Baseline June 1996 Water Table Versus September 2003 Water Table.

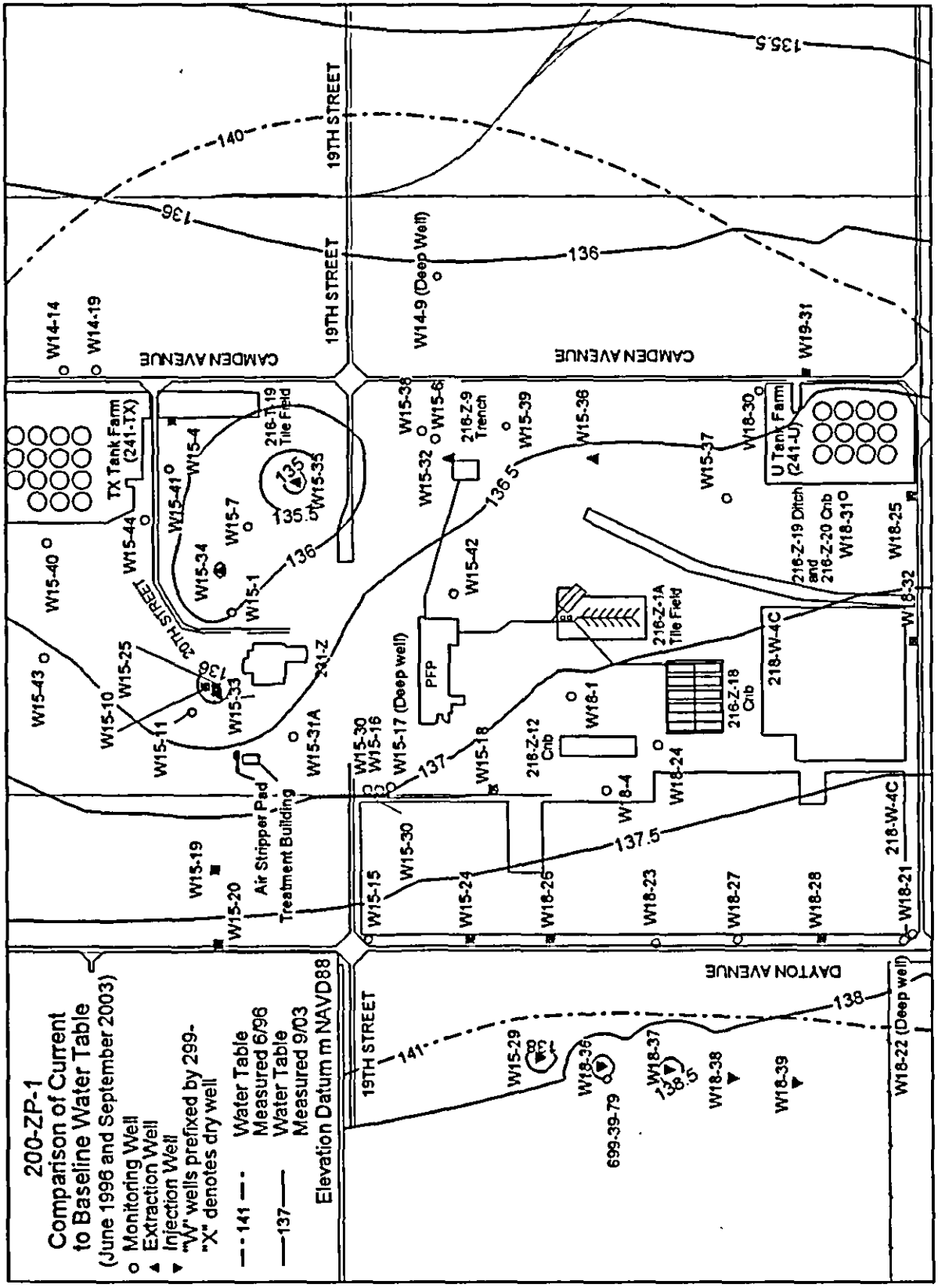


Figure 3-13. 200-ZP-1 Operable Unit Area of Hydraulic Capture Through September 2003.

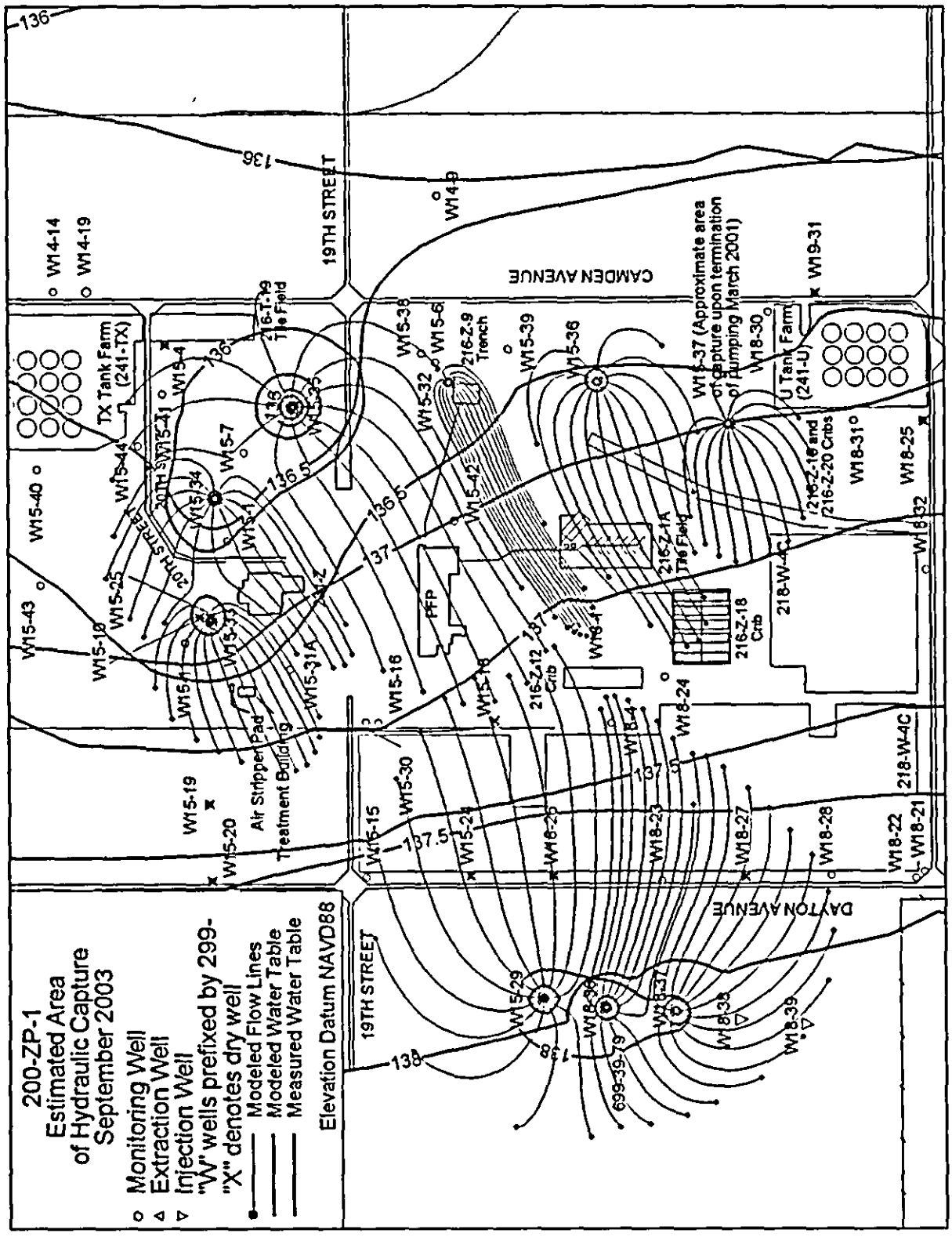


Table 3-1. Volume of Groundwater Treated and Carbon Tetrachloride Mass Removed Since Initiation of 200-ZP-1 Operable Unit Pump-and-Treat Operations. (2 sheets)

Reporting Period	Liters Treated	Mass of Carbon Tetrachloride Removed (kg)
August 1994 – July 1996	26,676,000	75.9
August 1996 – September 1996	33,232,327	61
October 1996 – December 1996	44,583,715	143.5
January 1997 – March 1997	69,869,903	237.2
April 1997 – June 1997	41,877,094	140.8
July 1997 – September 1997	62,469,305	228.8
October 1997 – December 1997	81,629,000	245.7
January 1998 – March 1998	72,791,000	279.5
April 1998 – June 1998	90,842,900	348.9
July 1998 – September 1998	90,899,200	338.1
October 1998 – December 1998	84,386,385	315.6
January 1999 – March 1999	77,079,401	310.2
April 1999 – June 1999	90,657,483	337.8
July 1999 – September 1999	88,657,767	323.7
October 1999 – December 1999	53,073,892	201.8
January 2000 – March 2000	90,920,220	370
April 2000 – June 2000	74,312,943	307.8
July 2000 – September 2000	82,096,586	303.7
October 2000 – December 2000	94,110,990	336.8
January 2001 – March 2001	85,367,099	330.5
April 2001 – June 2001	84,283,176	297.1
July 2001 – September 2001	75,085,163	261.9
October 2001 – December 2001	81,274,965	287.3
January 2002 – March 2002	80,386,480	289.9
April 2002 – June 2002	73,058,873	258.9

Table 3-1. Volume of Groundwater Treated and Carbon Tetrachloride Mass Removed Since Initiation of 200-ZP-1 Operable Unit Pump-and-Treat Operations. (2 sheets)

Reporting Period	Liters Treated	Mass of Carbon Tetrachloride Removed (kg)
July 2002 – September 2002	66,562,164	216.6
October 2002 – December 2002	61,253,813	200.4
January 2003 – March 2003	66,707,490	204.2
April 2003 – June 2003	66,077,797	223.2
July 2003 – September 2003	59,562,556	191.5
Totals	**2,149,785,687**	**7,668.3**

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4.0 PUMP-AND-TREAT SYSTEMS COST DATA

Actual costs for the 200-UP-1 and 200-ZP-1 OU pump-and-treat systems, recorded by the Environmental Restoration Contractor and FH since project startup, can be used to determine the actual capital and labor costs associated with a specific activity over a given period of time. Tables 4-1 and 4-2 provide comparisons of the costs for the 200-UP-1 OU and 200-ZP-1 pump-and-treat systems, respectively, from FY95 through FY03. These data have been used to estimate actual project costs (burdened) and projected future costs (based on actual costs to date). Specific activities are described below:

- **Initial design:** Includes initial design activities to support pump-and-treat system construction, permitting, aquifer response modeling, peer reviews, quality assurance, and all other design documentation. It also includes the design of system upgrades and modifications.
- **Treatment system capital construction:** Includes fees paid to the construction subcontractor for capital equipment, initial construction/construction of new wells, redevelopment of existing wells, and modifications to the pump-and-treat system. Includes all Environmental Restoration Contractor and FH labor required for oversight and support of well installation.
- **Project support:** Includes project coordination-related activities and technical consultation as required during the course of the facility design, construction, acceptance testing, and operation.
- **Operations:** This cost represents facility supplies, labor, and craft supervision costs associated with operating and maintaining the facility. It also includes costs associated with routine field screening and engineering support as required during the course of the pump-and-treat operations and periodic maintenance.
- **Performance monitoring:** Includes system and groundwater sampling and sample analysis as required in accordance with the interim action work plans (DOE-RL 1996b, 1997). It also includes development of this performance evaluation report and subsequent reports, as required by the interim action work plans.
- **Waste management:** This is the estimated cost for the management of GAC at the 200-ZP-1 OU in accordance with the applicable laws for suspect hazardous, toxic, and regulated wastes. It includes waste designation sampling and analysis. There are currently no charges to the 200-UP-1 OU project for groundwater treatment costs from the ETF.
- **Regeneration subcontract:** This includes cost for the regeneration of GAC used by the 200-ZP-1 OU treatment system.
- **Construction capital:** This includes the cost for reconfiguring an existing monitoring well as an extraction well and the cost of the design for tying this new extraction well into the transfer pipeline that conveys groundwater to the ETF for treatment.

- **Well installation:** This includes costs for installation of new monitoring and extraction wells at the 200-UP-1 and 200-ZP-1 OUs. A new monitoring well, 299-W19-46, was drilled for the 200-UP-1 OU. New 200-ZP-1 OU monitoring well 299-W15-42 and extraction well 299-W15-45 were drilled and completed.

4.1 200-UP-1 OPERABLE UNIT PUMP-AND-TREAT COSTS

The costs for operation of the 200-UP-1 OU pump-and-treat system are summarized in Figure 4-1 and Table 4-1. The FY03 costs are displayed by percent of the total costs in the pie chart in Figure 4-1. Costs per gram of constituent removed have increased from FY02 (DOE-RL 2003a) because installation and sampling of the new wells and conversion of monitoring wells for groundwater extraction at the 200-UP-1 OU. Groundwater production costs are $0.006/L. Based on the FY03 costs and the yearly groundwater production rate (98.3 million L [approximately 26 million gal]), the treatment costs can be summarized as follows (see Table 4-1 for further information):

- Uranium (21.2 kg of uranium removed) = $27.00/g of uranium removed
- Technetium-99 (11.8 g of technetium-99 removed) = $48,490/g of technetium-99 removed
- Carbon tetrachloride (2.8 kg of carbon tetrachloride removed) = $204/g of carbon tetrachloride removed
- Nitrate (4,158 kg of nitrate removed) = $0.14/g of nitrate removed.

Figure 4-1 shows that over one-half of the FY03 costs for the 200-UP-1 OU pump-and-treat project are associated with operations and maintenance, as well as the installation of a new monitoring well (299-W19-46). Construction capital includes the design cost for reconfiguring two existing monitoring wells (299-W19-43 and 299-W19-36) as extraction wells and the cost of tying the new extraction wells into the ETF transfer pipeline. Costs per gram of constituent removed have increased significantly from previous years because of installation of the new well and reconfiguration of wells for extraction at the 200-UP-1 OU. The ETF operating expenses are not factored into overall project costs.

The declining groundwater table is impacting the costs of system operation, due in part to the operations and maintenance costs resulting from increased pump maintenance. The RAO requirement to pump 189.3 L/min (50 gpm) and the need to provide a satisfactory monitoring capability for the plume also requires drilling new wells as existing wells go dry. To date, 10 wells that were previously active in earlier stages of pump-and-treat operations have gone dry. Two new wells have been drilled as replacements, and three additional wells are scheduled to be drilled around the baseline plume area for FY04 and FY05.

4.2 200-ZP-1 OPERABLE UNIT PUMP-AND-TREAT COSTS

The costs for operation of the 200-ZP-1 OU pump-and-treat system are summarized in Figure 4-2 and Table 4-2. The FY03 costs are displayed by percent of total costs in the pie chart in Figure 4-2. Based on the FY03 costs and yearly production rate (253.6 million L [approximately 67 million gal] of water and 819 kg of carbon tetrachloride removed), the FY03 treatment costs equate to $0.006/L of water and $1,940/kg of carbon tetrachloride removed.

Figure 4-2 shows that almost half of FY03 costs for the 200-ZP-1 U pump-and-treat project were associated with operations. The actual dollar cost for operations increased by approximately $246,000, to $724,800. Another 25% is associated with the new monitoring well 299-W15-43 and new extraction well 299-W15-45. A portion of the increase is the result of troubleshooting and repairing extraction problems at wells 299-W15-32 and 299-W15-33. A 13% savings in performance monitoring costs has resulted from a mid-year conversion to monthly (rather than bi-weekly) sampling and analysis.

Overall, the trends over the last 2 years suggest that some of the increased operating costs are resulting from declines in groundwater table elevations. New extraction wells are being drilled to replace old wells where declining water levels are causing decreases in overall extraction rates. The new wells are required to ensure adequate plume monitoring coverage. The new monitoring and extraction wells are more expensive because they are being drilled deeper, are constructed to larger diameters than monitoring wells, and they have greater lengths of expensive well screen installed to provide longer well life.

Figure 4-1. Cost Breakdown for 200-UP-1 Operable Unit Pump-and-Treat Operations. (3 sheets)

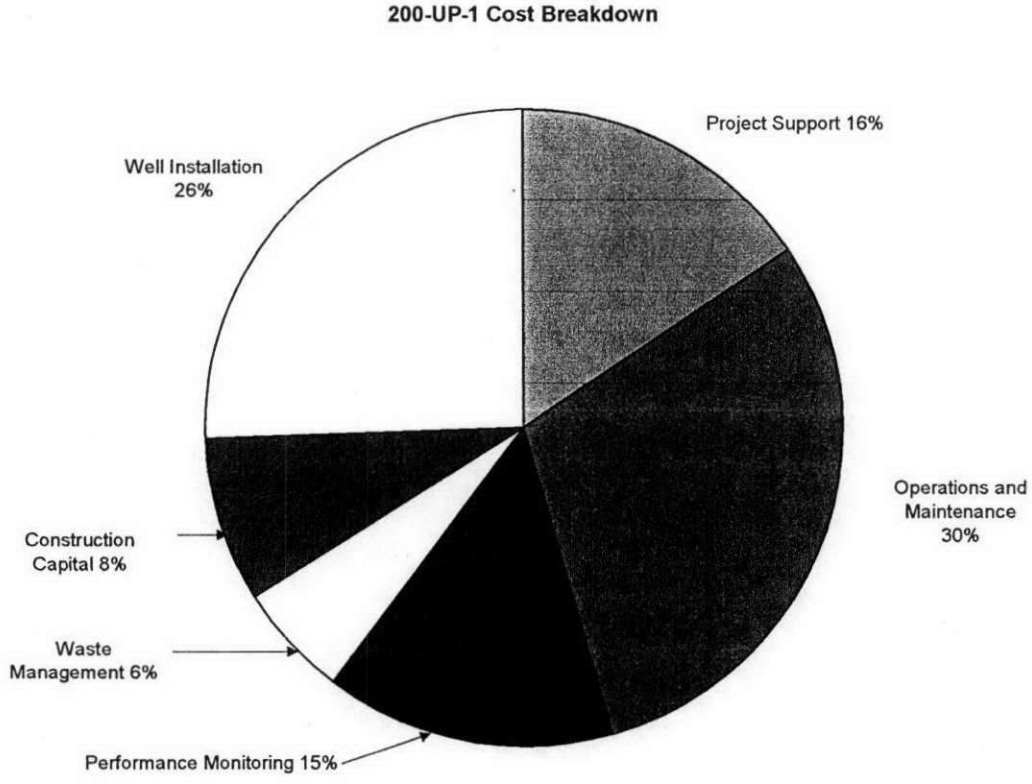
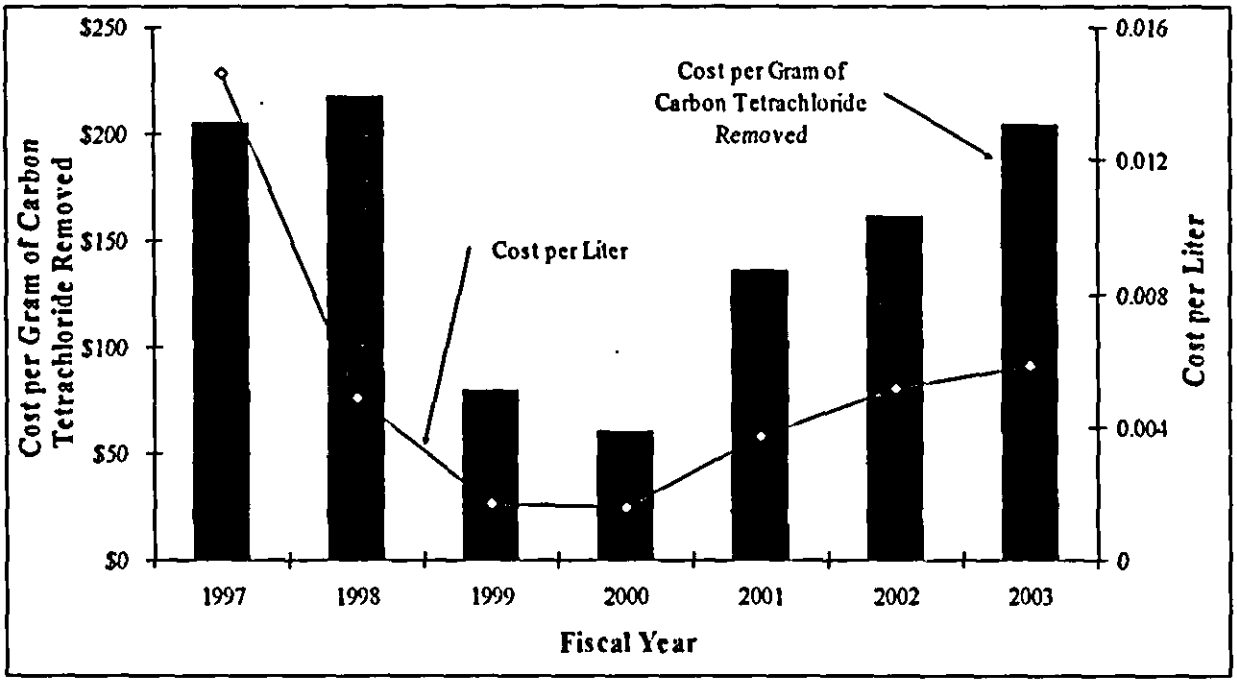


Figure 4-1. Cost Breakdown for 200-UP-1 Operable Unit Pump-and-Treat Operations. (3 sheets)



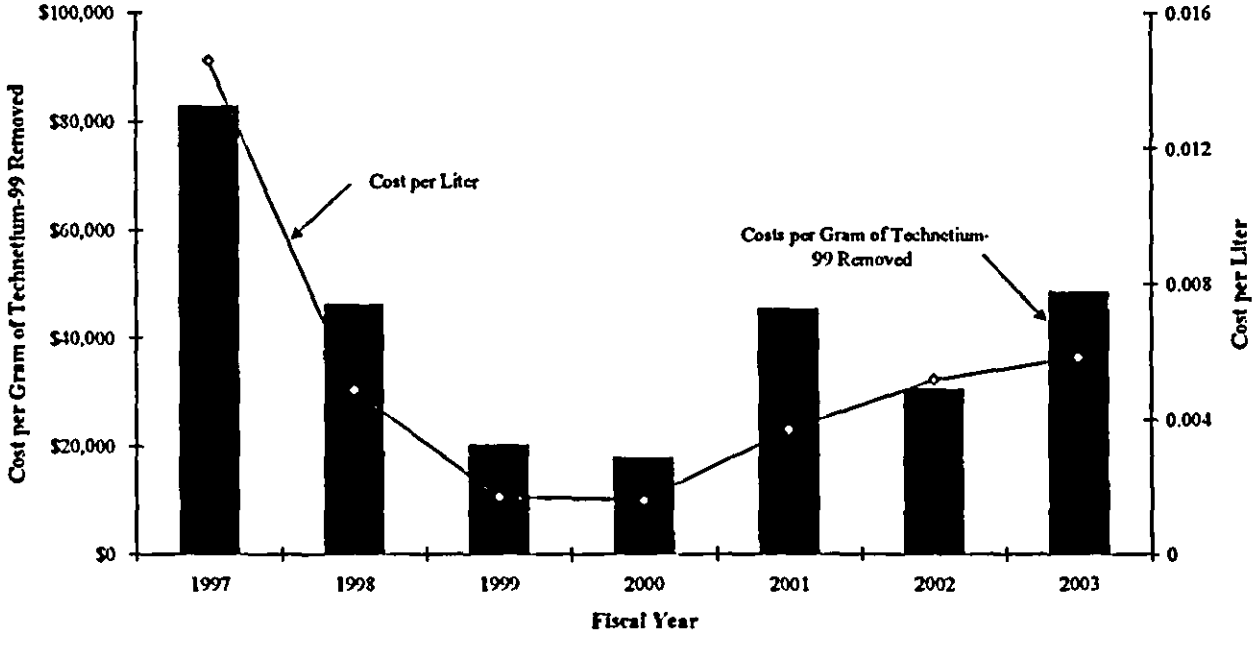
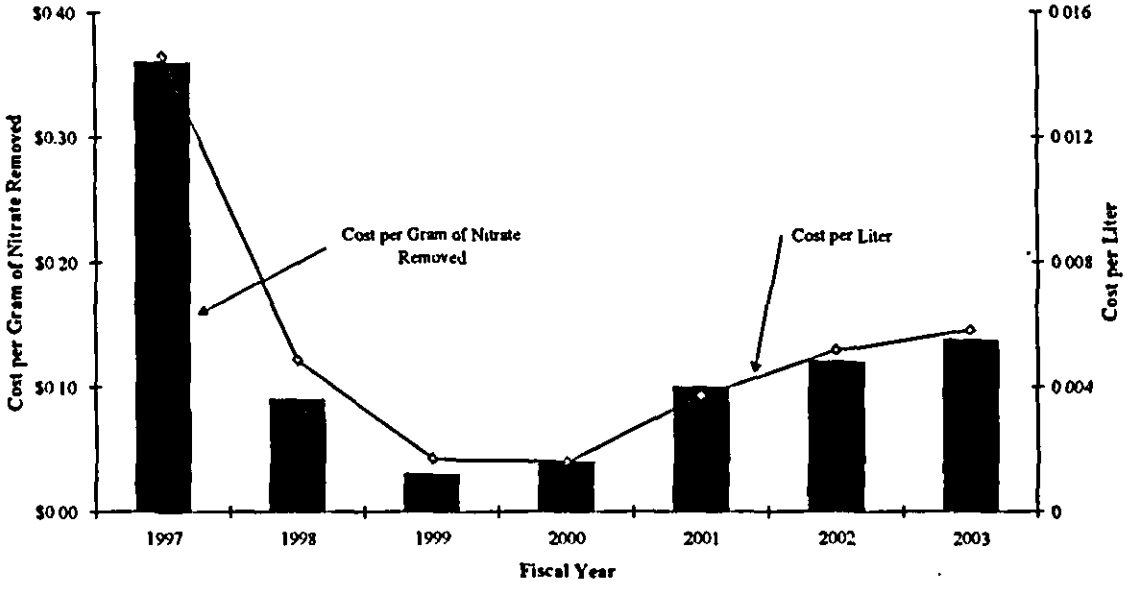


Figure 4-1. Cost Breakdown for 200-UP-1 Operable Unit Pump-and-Treat Operations. (3 sheets)



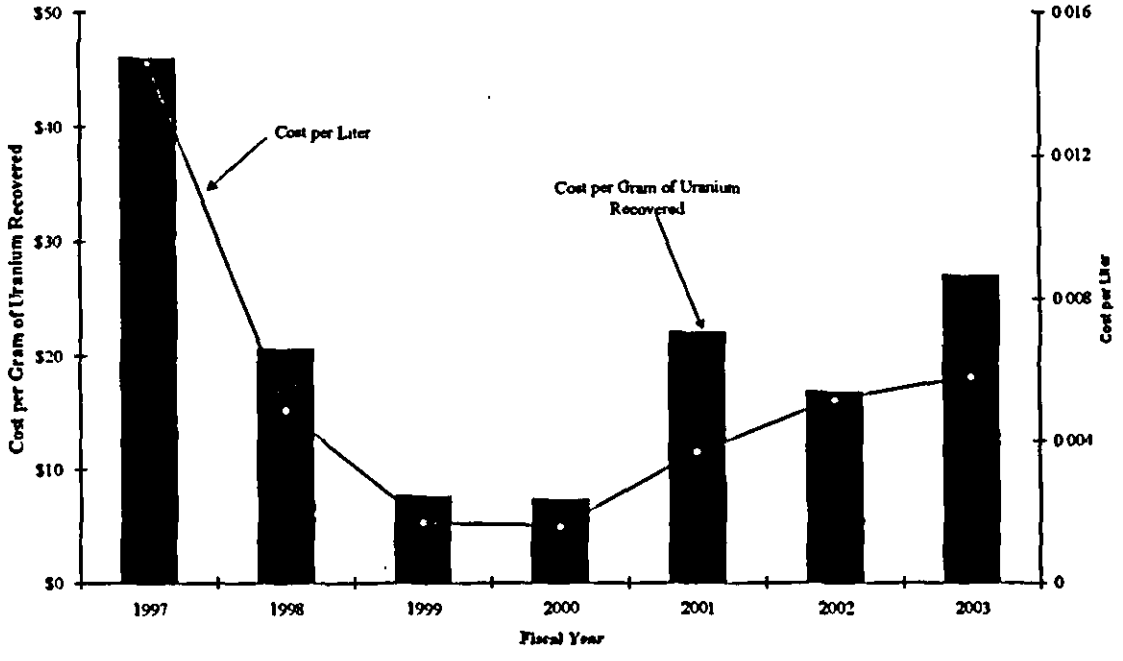
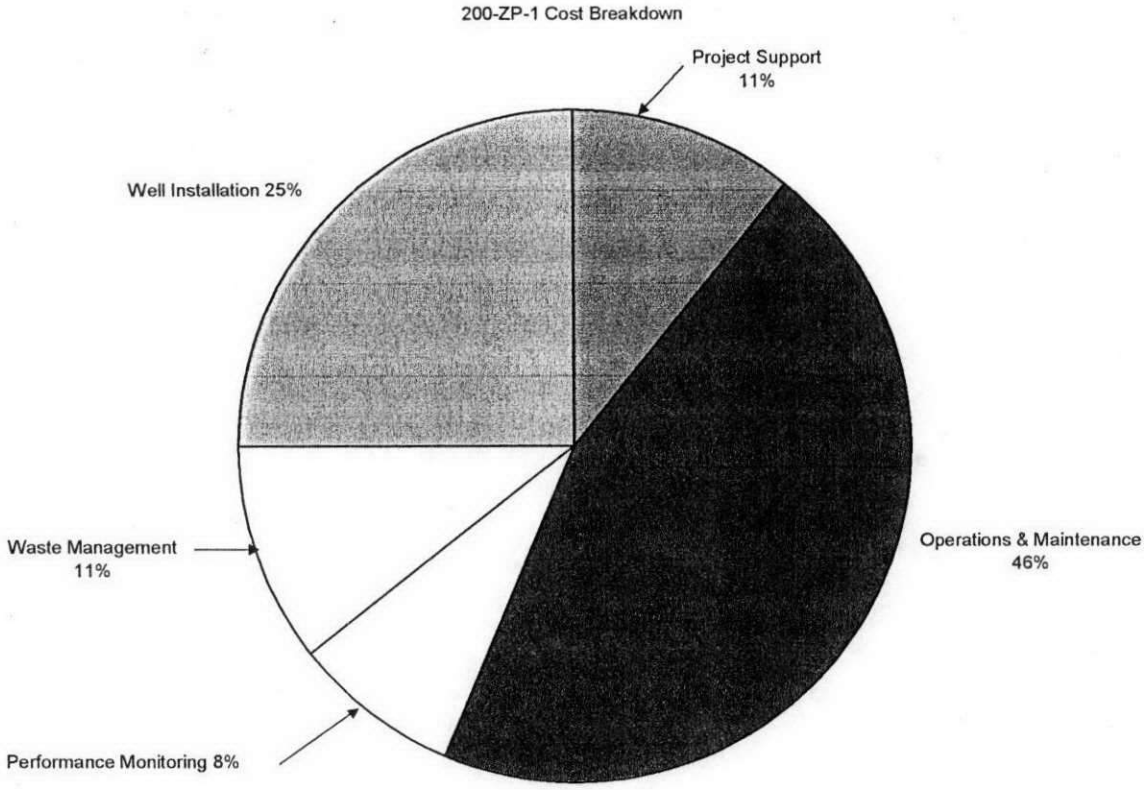


Figure 4-2. Cost Breakdown for 200-ZP-1 Operable Unit Pump-and-Treat Operations.



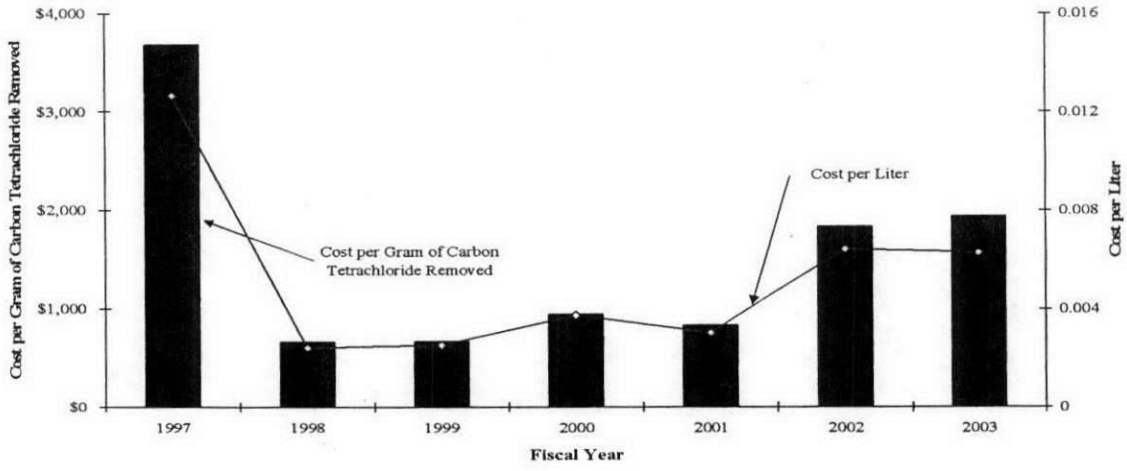


Table 4-1. Comparison of Yearly Costs for Operation of 200-UP-1 Pump-and-Treat System – Fiscal Year 1995 Through Fiscal Year 2003.

Description	Actual Costs (in $1,000)								
	1995	1996	1997	1998	1999	2000	2001	2002	2003
Initial design	1,503.10	511							
Project support			101	86	31.3	39.6	0.3	140.1	89.1
Operations & maintenance	2,821.00	2,135.00	707	400.8	127.8	18.8	52	78.4	171
Performance monitoring						32.2	35.9	33.1	84.3
Waste management						10	21.3	8.2	33.3
Construction capital							71.7	149.5	48.1
Well installation							198.5	34.1	145.9
Totals	**$4,324.1**	**$2,646.0**	**$808.0**	**$486.8**	**$159.1**	**$100.6**	**$379.7**	**$443.4**	**$571.7**

Table 4-2. Comparison of Yearly Costs for Operation of 200-ZP-1 Pump-and-Treat System – Fiscal Year 1995 Through Fiscal Year 2003.

Description	Actual Costs (in $1,000)								
	1995	1996	1997	1998	1999	2000	2001	2002	2003
Initial design	2,854.40	271							
Treatment system capital		3,992.00							
Project support			444	183.8	158.9	115.1	30.9	141.6	171.1
Operations & maintenance	1,139.00	6,010.00	2,320.00	626.2	704.5	701.3	550.8	478.4	724.8
Performance monitoring						256.9	177	146.1	127.6
Waste management						45.3	52.6	92.2	167.2
Regeneration subcontract							142.6		
Well installation							68	1,071.50	397.90
Totals	**$3,993.40**	**$10,273.0**	**$2,764.0**	**$810.0**	**$863.4**	**$1,118.6**	**$1,021.9**	**$1,929.8**	**$1,588.6**

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APPENDIX A

WASTE SITE, OPERABLE UNIT, AND PUMP-AND-TREAT HISTORY

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CONTENTS

TERMS

bgs	below ground surface
DOE	U.S. Department of Energy
DWS	drinking water standard
ETF	Effluent Treatment Facility
FY	fiscal year
GAC	granular activated carbon
gpm	gallons per minute
IX	ion exchange
MCL	maximum contaminant level
MTCA	*Model Toxics Control Act*
OU	operable unit
PFP	Plutonium Finishing Plant
ppm	parts per million
PUREX	Plutonium-Uranium Extraction (Facility)
PRF	Plutonium Reclamation Facility
RECUPLEX	Reclamation of Uranium and Plutonium by Extraction
REDOX	Reduction-Oxidation (Plant)
ROD	Record of Decision
SVE	soil vapor extraction
TCE	trichloroethene
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
UO_3	uranium trioxide
URP	Uranium Recovery Project
WAC	*Washington Administrative Code*
WIDS	Waste Information Data System

APPENDIX A

WASTE SITE, OPERABLE UNIT, AND PUMP-AND-TREAT HISTORY

A1.0 INTRODUCTION

This appendix describes the waste disposal operations and regulatory history for the 200-UP-1 and 200-ZP-1 Operable Unit (OU) pump-and treat systems. The data are provided to better understand the evolution of the current treatment approaches.

A2.0 200-UP-1 OPERATIONAL HISTORY

A2.1 WASTE DISPOSAL

The 216-U-1 and 216-U-2 Cribs, as well as the 241-U-361 tank, comprised a waste disposal system that received significant volumes of liquids from a series of uranium recovery processes. A reverse or injection well (299-W19-9) was also part of the system but was not used for waste disposal. The cribs are constructed of wood and are 3.7-m by 3.7-m by 1.2-m (12-ft by 12-ft by 4-ft)-high, open structures, resting at the bottom of 6.1-m (20-ft)-deep excavations. The two cribs were connected in series, requiring wastewater to overflow into the 216-U-2 Crib after backing up in the 216-U-1 Crib pipe.

Waste was derived from a variety of processes associated with uranium recovery and conversion to uranium trioxide from separations plant processes. The Uranium Recovery Project (URP) operated between 1951 and 1957, retrieving uranium from bismuth phosphate process metal wastes stored in the B, C, T, and U Tank Farms. The chemical separations process recovered the uranium using a tributyl phosphate-based solvent-extraction process conducted at the 221-U and 224-U Buildings. A related step in a separate part of the 224-U Facility converted batches of dilute uranyl nitrate hexahydrate into, first, concentrated uranyl nitrate hexahydrate, and then into uranium trioxide (UO_3) by calcining (i.e., heating) in furnaces. Concentrated uranyl nitrate from the 202-S Reduction-Oxidation (REDOX) Plant was also calcined into UO_3, as was material trucked from the 202-A Plutonium-Uranium (PUREX) Facility. Additions and modifications to the UO_3 process were made with the addition of the 224-UA and other supporting facilities, all of which permitted continuous calcining operations. The UO_3 process was active until 1989 and made a final cleanout run in 1992, following a related cleanout run at the PUREX Facility.

The nature of waste-generating activities at these facilities is not well documented. Piping in the 221-U Facility was decontaminated in 1966-1967 with acid washes, which were then discharged to the cribs. The Waste Information Data System (WIDS) database reports that the 216-U-1/2 Cribs received 4.62×10^7 L (1.22×10^7 gal) of process wastes from the URP and multiple UO_3 processes through 1967. The liquid wastes included trace to minor concentrations of uranium, which accumulated to 4,040 kg of uranium (Baker et al. 1988) at the waste site. However, Diediker (1999) lists an inventory of 0.701 Ci (2,096 kg) of total uranium, 6.82×10^{-4} Ci (0.012 g) of technetium-99, 1.7 Ci (0.017 g) of strontium-90, and 3.53 Ci (0.036 g) of cesium-137 (all values decayed through December 31, 1998). With the end of discharges to these cribs in 1967, other waste sites were either on-line or were brought into use for the waste

streams, primarily the following cribs: 216-U-8 (1952 through 1960), 216-U-12 (1960 through 1988), and 216-U-17 (1988 through 1994).

Groundwater contamination was discovered at the 216-U-1/2 Cribs in January 1985, when samples from two nearby wells, 299-W19-3 and 299-W19-11, revealed unusually high (up to 85,000 pCi/L) concentrations of uranium (Baker et al 1988, Delegard et al. 1985) compared with results from several weeks earlier. The contamination was attributed to startup of the 216-U-16 Crib, located 200 m (656.2 ft) south of the 216-U-1 Crib. This crib received large volumes of cooling water from 224-U between July 1984 and 1987. Boreholes were drilled to characterize the site and an ion-exchange (IX) system based at the 242-S evaporator was set up. The IX system treated approximately $3.0 \times 10^{+7}$ L (8 million gal) of groundwater and recovered 687 kg of uranium between June and November 1985. The WIDS database notes that an additional 830 kg of uranium were thought to remain in the groundwater after this pump-and-treat operation.

Fortuitously, well 299-W19-11, drilled approximately 10 m (32.8 ft) east of the 216-U-1 Crib in 1983, was sampled and logged before startup of the 216-U-16 Crib (Delegard et al. 1985). The 1983 data revealed the presence of significant quantities of uranium, up to 36,000 parts per million (ppm) at 10.8 m (35.4 ft) below ground surface (bgs), but was spread across the upper 8 m (26.2 ft) of soil column directly below the 6-m (19.7-ft)-deep crib. Uranium concentrations then generally decreased with depth before rising to 100 ppm at 50 m (164.1 ft) bgs near the Plio-Pleistocene caliche unit. Uranium concentration then declined to 0.01 ppm near the groundwater table. Gross gamma geophysical logging conducted in 1985, after the groundwater uranium increase, indicated that activities in sediments at 50 m (164.1 ft) were greater than those in surrounding sediments. The geophysical logging also indicated that activity levels at the water table were higher than those from the sediment layers above.

More detailed chemical analyses were performed on the 1983 soil samples (Delegard et al. 1985). For the samples at 10.8 m (35.4 ft), the sediment was found to be acidic from the wastes previously discharged and contained 0.3% phosphorous (by weight), plus 9 pCi/L of cesium-137 and 900 pCi/L of strontium-90. Uranium was detected by x-ray diffraction in association with phosphates derived from the original waste stream entering the URP. Uranium was also present in other forms in this sample.

Characterization activities after startup of the 216-U-16 Crib and the resulting uranium plume at the 216-U-1/2 Cribs included drilling four boreholes (299-W19-15 through 299-W19-18), sediment sampling and analysis, and installing groundwater wells to monitor plume behavior. The water table was detected at approximately 67 m (219.8 ft) bgs, and a discontinuous caliche layer was found at 51 m (167.3 ft). A perched water table from 216-U-16 discharges was reported to be 23 m (75.5 ft), 21 m (68.9 ft), and 8 m (26.2 ft) thick for wells 299-W19-15, 299-W19-16, and 299-W19-17, respectively, adjacent to the cribs and the water was found to be contaminated with uranium. Delegard et al. (1985) assumed that access to the aquifer was by holes in the caliche layer or by migration along well casings penetrating the caliche.

A2.2 CURRENT REMEDIATION ACTIVITIES

The current pump-and-treat program emerged in 1994 following a recommendation in the *200 West Groundwater Aggregate Area Management Study Report* (DOE-RL 1993) that uranium, technetium-99, and nitrate plumes should be remediated under an interim remedial

measure. This recommendation was implemented in an agreement between the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency, and the Washington State Department of Ecology as *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 2003) Milestone 13-93-03. The agreement specified an IX pump-and-treat system as the treatability test and identified uranium and technetium-99 as the primary contaminants of concern. The *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-92-76, currently being revised [DOE-RL 2004]) and the *Pilot-Scale Treatability Test Plan for the 200-UP-1 Groundwater Operable Unit* (DOE-RL 1994a) were prepared to guide development of the IX system. Carbon tetrachloride was added as a secondary contaminant of concern but nitrate was dropped as a target constituent for the treatability test.

The pilot-scale treatability test was constructed and operated between March 1994 and September 1995 (*Treatability Report for the 200-UP-1 Operable Unit – Hanford Site* [DOE-RL 1995c]). The treatability test consisted of an onsite pump-and-treat system constructed adjacent to the 216-U-17 Crib, plus single extraction (299-W19-24) and injection (299-W19-25) wells. Well 299-W19-23 was added as a backup extraction well and was brought on-line when pumping rates at well 299-W19-24 declined. Additionally, wells 299-W19-20, 299-W19-23, 299-W19-26, 299-W19-28, 299-W19-29, and 299-W19-30 (which were originally installed between 1986 and 1990 to monitor crib performance) were used to track plume behavior. Groundwater was extracted at a rate of 57 L/min (15 gallons per minute [gpm]). The IX technology was used to remove technetium and uranium, while granular activated carbon (GAC) was used for the secondary removal of carbon tetrachloride. The treatability test demonstrated that the IX and GAC technologies were effective at removing uranium/technetium-99 and carbon tetrachloride, respectively, from groundwater.

Following completion of the pilot test, pump-and-treat operations continued. A 1994-1995 drilling program installed eight new wells (299-W19-34A through 299-W19-40, 299-W19-34A, and 299-W19-34B monitored deeper groundwater conditions) to better define and monitor the plume. Phase I pump-and-treat operations commenced September 25, 1995, and continued until February 7, 1997, using the onsite plant and single new extraction (299-W19-39) and injection (299-W19-36) wells. Groundwater was extracted at a rate of 189.3 L/min (50 gpm). During this period, operations continued in anticipation of the release of the *Interim Remedial Measure Proposed Plan for the 200-UP-1 Operable Unit, Hanford, Washington* (DOE-RL 1995b) and issuance of an interim action Record of Decision (ROD).

On February 25, 1997, the *Record of Decision for the 200-UP-1 Interim Remedial Measure* (EPA et al. 1997) was issued for the 200-UP-1 OU pump-and-treat operations. The *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan* (DOE-RL 1997a) was prepared to describe the detailed design of the treatment system. The selected remedy consisted of pumping from the highest concentration zone of the uranium and technetium-99 groundwater plumes and routing the groundwater to the Effluent Treatment Facility (ETF) in the 200 East Area for treatment. System operations were shut down from February 8 to March 30, 1997, to connect the extraction well to the pipeline conveying groundwater to the ETF.

The selected remedy section of the 200-UP-1 interim action ROD (EPA et al. 1997) established the high-concentration zone for technetium-99 as the area contained within the 9,000 pCi/L contour, equal to 10 times the 900 pCi/L maximum contaminant level (MCL). For uranium, the selected remedy's high-concentration zone was a contour set at 480 µg/L, or 10 times the 1997

Model Toxics Control Act (MTCA) (*Washington Administrative Code* [WAC] 173-340) standard of 48 μg/L. Since then, the MTCA standard has been lowered twice, first to 40 μg/L and in fiscal year 2003 (FY03) to 30 μg/L. The pump-and-treat system continues to be evaluated against the ROD's selected remedy value of 10 times the 48 μg/L MTCA standard, or 480 μg/L.

Phase II operations were initiated on March 31, 1997, and continue to the present. During Phase II, contaminated groundwater has been transported 11.3 km (7 mi) through a pipeline from the extraction wells in the 200 West Area to the ETF for treatment. After treatment, groundwater is discharged to the State-Approved Land Disposal Site, located north of the 200 West Area.

For additional site characterization and background information on the 200-UP-1 OU and pump-and-treat activities, refer to the following documents:

- *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit* (DOE-RL 2004)
- *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan* (DOE-RL 1997)
- *Engineering Evaluation/Conceptual Plan for the 200-UP-1 Groundwater Operable Unit Interim Remedial Measure* (BHI 1996b).

Information regarding the progress of the 200-UP-1 OU pump-and-treat operations is provided in the following documents:

- *200-UP-1 Groundwater Pump-and-Treat Phase I Annual Report, FY 1996* (BHI 1996a)
- *Fiscal Year 1997 Annual Report for the 100-NR-2, 200-UP-1, and 200-ZP-1 Pump-and-Treat Operations and Operable Units* (BHI 1998)
- *Fiscal Year 1998 Annual Summary Report for the 200-UP-1, 200-ZP-1, and 100-NR-2 Pump-and-Treat Operations and Operable Units* (DOE-RL 1999)
- *Fiscal Year 1999 Annual Summary Report for the 200-UP-1, 200-ZP-1, and 100-NR-2 Pump-and-Treat Operations and Operable Units* (DOE-RL 2000)
- *Fiscal Year 2000 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations* (DOE-RL 2001)
- *Fiscal Year 2001 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*(DOE-RL 2002b)
- *Fiscal Year 2002 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations* (DOE-RL 2003).

At present, low volumes of effluents are being discharged to the 2607-W5 septic tank tile field, which lies just north of the 216-U-1/2 Cribs. In addition, aging and potentially leaky water, steam, and high-activity transfer lines criss-cross the area around the 216-U-1/2 Cribs and the 221-U Canyon Building and its connecting pipelines. A water line failure just south and west of the two cribs discharged 6.4 million L (1.7 million gal) of water to the soil column between July 23 and November 22, 2002. Another leak of unknown but low volume occurred in June 2003 at a location further west of the 216-U-1/2 Cribs. Incidents such as these have raised concern that leaks provide a driving force for contaminant movement and may occur as either full-time or on temporary discharges.

At the end of FY03, the current pump-and-treat system has removed 179.5 kg of uranium and 102.0 g of technetium-99. Including the 1985 pump-and-treat action, over 863 kg of uranium have been removed from parts of the uranium plume.

A3.0 200-ZP-1 OPERABLE UNIT

A3.1 WASTE SITE OPERATIONAL HISTORY

The 216-Z-9 Trench received organic and aqueous waste from the Reclamation of Uranium and Plutonium by Extraction (RECUPLEX) process at the Plutonium Finishing Plant (PFP) between 1955 and 1962. RECUPLEX was a solvent extraction process used to recover plutonium from plutonium metal and compound scraps. Tributyl phosphate mixed 15% to 20% by volume with carbon tetrachloride removed plutonium in the exchange process from the inorganic acid feed (FDH 1997). The plutonium was then removed from the tributyl phosphate/carbon tetrachloride organic solution and converted to plutonium nitrate, which became part of the feed for the plutonium-refining process at the 234-5Z PFP. The tributyl phosphate/carbon tetrachloride solution was treated and then discharged to the soil column at the 216-Z-9 Trench.

Scrap reprocessing was next performed at the 236-Z Plutonium Reclamation Facility (PRF) between 1964 and 1987 (FDH 1997). Wastes were sent to the soil column at the 216-Z-1A tile field between 1964 and 1969 and to the 216-Z-18 Crib between 1969 and 1973. After this, organic mixtures containing carbon tetrachloride wastes were no longer discharged to the soil column.

In addition to the above, the 242-Z Waste Treatment Facility (in service between 1963 and 1976) was involved with the recovery of americium-241 and plutonium in an IX batch process using 30% dibutyl butyl phosphonate and 70% carbon tetrachloride between 1964 and 1970. Wastes from this process were also discharged to the disposal sites receiving the PRF waste.

From the above sources, carbon tetrachloride was discharged to the ground during operations at the 234-5Z PFP between 1955 and 1973. Estimated quantities of carbon tetrachloride discharged to the waste sites vary between 363,000 to 580,000 L (95,900 to 153,200 gal, or 577,000 to 922,000 kg) of liquid carbon tetrachloride. The waste was discharged primarily to three sites: 216-Z-1A (268,000 kg/168,600 L), 216-Z-9 (471,000 kg/296,300 L), and 216-Z-18 (173,800 kg/109,300 L) between 1955 and 1973 (*Waste Site Grouping for 200 Areas Soil Investigations* [DOE-RL 1997b]). Three other sites, the 216-T-19 and 216-Z-12 Cribs and the 216-Z-19 Ditch, also are known or suspected to have received quantities of carbon tetrachloride and were active between 1959 and 1981.

Over 2,700,000 kg of nitrate were also discharged to the six sites, and a plume has formed roughly coincident with the part of the carbon tetrachloride plume north of the waste sites.

Chloroform, a secondary contaminant of concern for the interim remedial measure, is a degradation product of carbon tetrachloride (Truex et al. 2001). Chloroform (drinking water standard [DWS] = 80 μg/L) is also associated with septic waste disposal. The 2607-Z septic system and drain field (active from 1949 to 1999) are located east of the 234-5Z Building and may have been the source of high chloroform detections (up to 680 μg/L) during vertical profile sampling at well 299-W15-42. The WIDS database reports an estimated discharge in 1992 of 23,000 L/day (6,076 gal/day). The 1996 baseline chloroform plume generally mimicked the

outline of the high-concentration baseline carbon tetrachloride plume but at much lower concentrations. The current chloroform plume is depicted around all of the extraction wells.

The origin of trichloroethene (TCE) in waste streams is unknown but is thought to have been used as a degreaser. A baseline TCE (DWS = 5 μg/L) plume was not prepared in 1996 because of low TCE concentrations at carbon tetrachloride monitoring wells. Currently, the TCE plume is centered around wells 299-W15-34 and 299-W15-35 and extends north towards the 241-TY Tank Farm.

A3.2 REMEDIATION TREATMENT ACTIVITIES

Carbon tetrachloride was first detected in groundwater samples from several wells in 1986 (*Environmental Monitoring at Hanford for 1986* [PNL 1987]) and was recognized as a broad plume beneath the 200 West Area in 1987. The *200 West Area Groundwater Aggregate Area Management Study Report* (DOE-RL 1993) discussed the groundwater carbon tetrachloride plume and recommended it for an expedited response action. It became the target of an expedited response action when the regulators requested that DOE assess groundwater contamination and evaluate alternatives for carbon tetrachloride contamination in the 200 West Area. A treatability test plan proposed (DOE-RL 1994b) and implemented a treatment system, which later became Phase I of the 200-ZP-1 pump-and-treat system.

In a separate and preceding action, the regulators requested that DOE assess carbon tetrachloride in the vadose zone (200-ZP-2, currently 200-PW-1) and evaluate alternatives to treat the contaminant. This led to preparation of the *Expedited Response Action Proposal (EE/CA & EA) for 200 West Carbon Tetrachloride Plume* (DOE-RL 1991). Soil vapor extraction (SVE) was recommended and implemented for the 216-Z-9 Trench and the 216-Z-1A tile field and the 216-Z-18 Crib. Initially, one system was built and operated for each of the three waste sites. Operations are currently conducted between April 1 and September 30 each year. Passive SVE systems have also been installed at eight boreholes around the 216-Z-18 Crib. Among other topics, the *Performance Evaluation Report for Soil Vapor Extraction Operations at the 200-PW-1 Carbon Tetrachloride Site, Fiscal Year 2002* (FH 2003) reports on SVE site operations and vadose zone conditions.

The 200-ZP-1 OU pump-and-treat system was implemented in a three-phased approach. Phase I operations consisted of the pilot-scale treatability test between August 29, 1994, and July 19, 1996, around the 216-Z-12 Crib. During this phase, contaminated groundwater was removed through a single extraction well (299-W18-1) at a rate of approximately 151 L/min (40 gpm), treated using GAC, and returned to the aquifer through an injection well (299-W18-4). For more detailed information about operations during the treatability test, refer to the *200-ZP-1 Operable Unit Treatability Test Report* (DOE-RL 1995a).

Concurrent with Phase I operations, the *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* (EPA et al. 1995) was issued in June 1995. The selected remedy was to use groundwater pump-and-treat technology to minimize further migration of carbon tetrachloride, chloroform, and TCE in the groundwater and remove mass.

Phase II operations commenced August 5, 1996, in accordance with the interim action ROD (EPA et al. 1995) and Tri-Party Agreement Milestone M-16-04A. The 1996 groundwater plume was the basis for the interim action ROD. The well field configuration during Phase II operations consisted of three extraction wells (299-W15-33, 299-W15-34, and 299-W15-35),

pumping at a combined rate of approximately 567.8 L/min (150 gpm), and a single injection well (299-W15-29). Groundwater was treated using an air stripper to release carbon tetrachloride into a vapor phase, and GAC was used to collect the vapor. For a detailed description of the treatment system setup and operation, refer to the *200-ZP-1 Phase Interim Remedial Measure Quarterly Report, October – December 1996* (BHI 1997). Phase II operations were terminated on August 8, 1997, to transition to Phase III operations.

Phase III operations began on August 29, 1997, satisfying Tri-Party Agreement Milestone M-16-04B. The well field for Phase III operations was expanded to include six extraction wells (existing, plus new wells 299-W15-32, 299-W15-36, and 299-W15-37) and five injection wells (existing, plus 299-W18-36, 299-W18-37, 299-W18-38, and 299-W18-39). The total pumping rate was increased to more than 800 L/min (+200 gpm), versus a total treatment system capacity of 1,893 L/min (500 gpm). The treatment process for the Phase III system uses the same air-stripping and GAC systems for remediating contaminated groundwater. Extraction wells were installed to contain the high-concentration portion of the carbon tetrachloride plume located near the PFP, as required by the interim action ROD (EPA et al. 1995). The southernmost extraction well, 299-W15-37, was converted to a monitoring well in January 2001 because of its limited impact on hydraulic capture of the high-concentration portion of the plume (DOE-RL 2002b).

For additional site characterization and background information on the 200-ZP-1 OU and the pump-and-treat activity, refer to the following documents:

- *Engineering Evaluation/Conceptual Plan for the 200-ZP-1 Operable Unit Interim Remedial Measure* (BHI 1994)
- *200-ZP-1 IRM Phase II and III Remedial Design Report* (DOE-RL 1996)
- *Hydrogeologic Conceptual Model for the Carbon Tetrachloride and Uranium/ Technetium Plumes in the 200 West Area: 1994 Through 1999 Update* (BHI 1999).

Information regarding the progress of the 200-ZP-1 OU pump-and-treat operations is provided in the following documents:

- *200-ZP-1 Operable Unit Treatability Test Report* (DOE-RL 1995a)
- *Fiscal Year 1997 Annual Report for the 100-NR-2, 200-UP-1, and 200-ZP-1 Pump-and-Treat Operations and Operable Units* (BHI 1998)
- *Fiscal Year 1998 Annual Summary Report for the 200-UP-1, 200-ZP-1, and 100-NR-2 Pump-and-Treat Operations and Operable Units* (DOE-RL 1999)
- *Fiscal Year 1999 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations and Operable Units* (DOE-RL 2000)
- *Fiscal Year 2000 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations* (DOE-RL 2001)
- *Fiscal Year 2001 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Operable Unit Pump-and-Treat Operations* (DOE-RL 2002b)
- *Fiscal Year 2002 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Operable Unit Pump-and-Treat Operations* (DOE-RL 2003).

By 1995, all of the liquid waste discharges around the PFP and baseline plume had been terminated. The 2607-Z tile field was taken out of service in 1999. A variety of water, steam, and process lines pass across the area and may provide an opportunity for leaks, but none have been reported. By the end of FY03, the 200-ZP-1 pump-and-treat system has removed 7,668 kg of carbon tetrachloride. Combined with the more than 78,000 kg removed by the SVE systems, more than 85,000 kg of carbon tetrachloride have been recovered.

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APPENDIX B

TREATMENT SYSTEM PERFORMANCE

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FIGURES

TABLES

TERMS

DWS	drinking water standard
ETF	Effluent Treatment Facility
FY	fiscal year
gpm	gallons per minute
ID	identification
LERF	Liquid Effluent Retention Facility
OU	operable unit
PFP	Plutonium Finishing Plant
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*

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APPENDIX B

TREATMENT SYSTEM PERFORMANCE

This appendix presents a detailed look at aspects of pump-and-treat system performance at the 200-UP-1 and 200-ZP-1 Groundwater Operable Units (OUs). It also discusses historic trends in both groundwater extraction and treatment at each facility.

B1.0 200-UP-1 OPERABLE UNIT PUMP-AND-TREAT SYSTEM PERFORMANCE

The pump-and-treat system at the 200-UP-1 OU is located southeast of U Plant (221-U) (see Figure 1-1). The system is designed to contain the high-concentration portions of the technetium-99 and uranium plumes originating from the 216-U-1 and 216-U-2 Cribs and to reduce the concentrations in these plumes. Carbon tetrachloride and nitrate are secondary contaminants of concern. This section presents an expanded discussion over that provided in Sections 2.2 through 2.4 in the main body of this document.

B1.1 EXTRACTION SYSTEM OPERATIONS

Based on individual well totalizers, the 200-UP-1 system extracted over 91,149,300 L (24,029,000 gal) of water. By comparison, the flow totalizer at the receiving end into the Liquid Effluent Retention Facility (LERF) reported 93,919,000 L (24,811,000 gal) for the year. The Effluent Treatment Facility's (ETF's) treated groundwater data, the record basis for quantities of groundwater treated and mass of contaminants removed, reported processing 98,344,000 L (25,980,000 gal). The differences in totalizer and flow rate values is attributable in part to system flow meter variability. Also, there was some carryover of groundwater pumped in fiscal year 2002 (FY02) and processed at the ETF at the beginning of FY03.

Differences in flow rates between the well heads and the LERF are important to determine if the system is leaking (Procedure POP-30-001, *Effluent Treatment Facility Control Room Rounds*, http://apweb02/wmpdol.) Most flow rate differences throughout the course of FY03 were less than 2% (under 3 L/min [0.79 gallons per minute {gpm}]). The ETF did not report any pipeline system leaks.

The average extraction system pumping rate for the year was 178.2 L/min (47.1 gpm) versus the remedial design goal of 189.3 L/min (50 gpm). Well 299-W19-39 operated all year, averaging 143.9 L/min (38 gpm). Well 299-W19-36 operated from October 1, 2002, to May 15, 2003, and averaged 31 L/min (8.2 gpm) for the time period. At that point, it was shut down to move the pump and well head equipment to well 299-W19-43. Pump and impeller problems at well 299-W19-43 kept that well off-line for most of June 2003. The well was restarted on July 1 and ran for the duration of the year. When running, the pumps at wells 299-W19-39 and 299-W19-43 combined for an average of 195.7 L/min (51.7 gpm) over the period. Well 299-W19-36 was refitted for extraction in late FY03 and will be used in FY04 to maintain or supplement the 189.3 L/min (50 gpm) remedial action objective (RAO) pumping rate.

For FY03, the extraction system experienced 231 hours of scheduled outages and 45 hours of unscheduled outages. Scheduled outages consist of time not operated due to system maintenance requirements, shutdowns at the LERF to receive other waste streams, Sitewide power utility shutdowns, etc. The LERF receives liquid waste from the ERDF cells in the form of leachate collected in a 681,400-L (180,000-gal) tank. The leachate is typically composed of sprinkler water for dust control and natural precipitation that have percolated through the contained waste. The leachate pipeline ties into the 200-UP-1 pump-and-treat pipeline near the 299-W19-39 extraction well. The leachate is pumped at a rate of approximately 757 L/min (200 gpm) and typically requires a temporary, 12- to 15-hr shutdown of 200-UP-1 extraction wells.

Unscheduled outages are the result of system shutdowns from low water-level sensors "tripping off" the pumps and other "preventable" system shutdowns. Based on these numbers, the extraction system had an on-line availability of 96.8% (hours operating/total hours in the FY) compared to 89.2% for FY02. The extraction system had a total system availability (hours operating/total hours in FY - scheduled outages) of 99.5% compared to 97.8% for FY02. The last 4 years of operations are summarized in Table B-1.

Based on single sample values in FY03 for each extraction well at 200-UP-1, a cumulative average concentration of the four contaminants of concern, weighted for the wells' individual concentrations and extraction volumes, has been computed. The average annual extraction concentrations for FY98 through FY03 are presented in Table B-2. A distinct increase is evident in FY02 following startup of pumping at well 299-W19-36 in the upgradient portion of the baseline plume. Only FY02 and FY03 data have required adjustments for cumulative flow from multiple wells.

B1.2 TREATMENT SYSTEM PERFORMANCE

For FY03, the ETF reported treating 98.3 million L (26 million gal) of contaminated water from the 200-UP-1 OU. Included in this total is 10,763 L (2,843.3 gal) of technetium-99–bearing water from well 299-W23-19. Since startup of remediation in FY94, almost 707.5 million L (187 million gal) have been treated (Table B-3). Quantities of primary and secondary contaminants removed in FY03 and since inception of treatment in 1994 are presented in Table B-2. Figures B-1 through B-3 present the quarterly cumulative extracted groundwater volume versus mass of primary and secondary contaminants removed.

Removal efficiency at the ETF was reported to be 100% for technetium-99, uranium, and carbon tetrachloride. All post-treatment samples for these analytes were reported as less-than-detect values. For nitrate, detectable concentrations of 40 µg/L were reported for some samples and yielded occasional removal efficiencies of 99.9%. Pre-treatment sampling in the LERF is performed monthly. Post-treatment tank sampling is performed prior to discharging the treated liquid to the State-Approved Land Disposal Site.

B1.3 WASTE TREATMENT

The 200-UP-1 groundwater pump-and-treat system provides approximately 85% to 90% of the wastewater treated at the ETF. A large quantity of solid waste is generated by the plant. The primary treatment train includes filtration, ultraviolet/oxidation, reverse osmosis, and ion-exchange systems. Liquid and solid wastes are generated by periodic cleanouts of these components. The liquids are treated by a secondary treatment system, which includes final

concentration and evaporation steps leading to a powder waste. The powder is drummed and disposed at the Environmental Restoration Disposal Facility. Other waste streams are also generated and disposed accordingly. Contact-contaminated clothing, filter media, parts, and equipment are drummed or boxed for disposal.

During FY03, the ETF treatment process shipped the following solid wastes:

- 461 – 208-L (55-gal) drums of powder waste
- 9 – 208-L sludge waste drums
- 3 – 3.63-m^3 (128-ft^3) contact waste boxes
- 7 – 1-m^3 (37-ft^3) "Maverick" contact waste boxes.

Table B-2 presents a comparison of waste generated between FY98 and FY03.

B1.4 CONTAMINANT MONITORING

Technetium-99 and uranium concentrations have at least temporarily declined below or to the respective RAO concentrations at all wells supporting the 200-UP-1 pump-and-treat system, based on the most recent sampling results. Additional sampling is required to determine if this is a short-term or permanent trend. Table B-4 summarizes periodic sampling for FY03 and compares it against trends at active monitoring wells since FY98. Trend plots for the active and recently inactive monitoring wells are presented in Appendix D. For most active wells, technetium-99 and uranium concentrations are declining.

B1.5 EXTRACTION WELLS – TECHNETIUM-99

All extraction wells at the 200-UP-1 pump-and-treat system are reporting technetium-99 concentrations below the 9,000 pCi/L RAO. The primary extraction well, 299-W19-39, which has never exceeded 1,660 pCi/L of technetium-99, declined to 952 pCi/L in January 2003.

Well 299-W19-36 was in use as an extraction well during the January 2003 sampling event and had declined to 4,600 pCi/L from the previous average concentration of 8,915 pCi/L in August 2002. This well was initially used for injection during Phase I of the 200-UP-1 pump-and-treat system and was not monitored at that time. Upon startup of Phase II, it was converted to a monitoring well and remained well below the 9,000 pCi/L technetium-99 RAO for the next 18 months. A sharp increase in April 1999 to 5,310 pCi/L presaged a rapid increase to 27,700 pCi/L by November 2002. Thereafter, concentrations declined to below the RAO by August 2002. It is assumed that the high-concentration spike is related to re-establishing the regional flow in the affected area about the well.

Well 299-W19-43 was drilled at the end of FY01 and sampled beginning in FY02. The first concentration, 14,700 pCi/L, was above the RAO and peaked at year's end at 22,400 pCi/L. The FY03 concentrations declined slowly under regional flow to 18,400 pCi/L in January 2003. With the start of extraction pumping in late May 2003, the technetium-99 level decreased sharply, to 3,390 pCi/L by the July sampling event. This concentration was reached after only 10 days of pumping following restart of the well, which had been shut down during most of June. Overall, the well had run for only 26 days of pumping following conversion to an extraction well before sampling.

B1.6 MONITORING WELLS – TECHNETIUM-99

A number of monitoring wells around the baseline plume area continued to show declining technetium-99 concentrations. However, two wells showed increases: 299-W19-35 was up 39% to 795 pCi/L over the previous value, and 299-W19-37 was up 85% to 808 pCi/L over the previous sample. For well 299-W19-35, 795 pCi/L is the highest recorded technetium-99 value since the start of monitoring in May 1994. This value is regarded more as an indication of sampling variability than an indication of an upward trend. Well 299-W19-35 is located downgradient of the uranium and technetium-99 plumes and monitors the control that pumping has on plume migration. This well will be sampled semi-annually in FY04.

For well 299-W19-37, the 808 pCi/L concentration is the highest since the February 2000 average value of 1,073 pCi/L. However, technetium-99 concentrations have declined sharply at this well from when first sampled in October 1995 at 17,400 pCi/L. By August 1997, the concentration reached a low of 1,350 pCi/L. The concentration rebounded to 4,600 pCi/L in April 1998 before beginning a long decline to the current level. This well is located downgradient of the FY02 uranium and technetium-99 RAO plumes at extraction wells 299-W19-36 and 299-W19-43. This recent increase is also viewed as an indication of sampling variability rather than any long-term trend. This well will also be sampled semi-annually in FY04.

Well 299-W19-40 is located downgradient of extraction well 299-W19-39 and monitors the overall pump-and-treat system's control on technetium-99 and uranium plume migration. Outside of one suspect sample with a concentration of 19,000 pCi/L (February 1996) and the initial sample value of 2,110 pCi/L in December 1995, technetium-99 concentrations have never been above 655 µg/L. In general, concentrations have slowly declined, reaching a January 2003 concentration of 170 µg/L.

Well 299-W19-20 went dry in March 2003 following the January sample event. Technetium-99 concentrations were at 838 pCi/L. Technetium-99 concentrations at this well began in December 1987 at 11,600 pCi/L and rose steadily to 17,700 pCi/L by March 1989. A sharp spike to 25,400 pCi/L was observed with the next sample (October 1998). Following a 27-month hiatus, one or two rounds of sampling for the 200 West Area groundwater aggregate area management study were undertaken. Technetium-99 concentrations ranged from 12,200 to 17,800 pCi/L, respectively, in January 1992 and February 1993. With the start of pump-and-treat treatability test operations, monthly sampling was conducted. For the first 3 months, concentrations at well 299-W19-20 ranged between 9,765 and 16,060 pCi/L. By December 1996, the last above-RAO concentration, at 9,800 pCi/L, had been observed and thereafter technetium-99 levels slowly declined to 4,160 pCi/L in July 2001. Over the next year, technetium-99 levels dropped from 1,840 pCi/L in January 2002 to 1,140 pCi/L in August 2002.

Well 299-W19-46 was drilled in November 2002 and sampled to establish a vertical profile for the contaminants of concern. Technetium-99 reached a maximum concentration of 1,360 pCi/L at a depth of 18.5 m (60.8 ft) below top of groundwater. The second highest concentration, 715 pCi/L, was at a depth of 24.6 m (80.7 ft) below top pf groundwater. Other samples ranged between 55.7 and 215 pCi/L to a depth of 36.2 m (118.8 ft) below top of groundwater. Quarterly sampling in FY03 yielded concentrations between 139 and 174 pCi/L. By comparison, well

299-W19-38 started at 270 µg/L in August 1995, peaked in July 1998 at 5,000 µg/L, and declined to an average value of 750 µg/L at the last sampling event in January 2000.

B1.7 EXTRACTION WELLS – URANIUM

By the end of the year, uranium concentrations had also declined to below RAOs in all but one of the extraction wells. Only well 299-W19-43 was exactly at the uranium RAO of 480 µg/L in July 2003, although it had declined to 1,190 µg/L in the January 2003 sampling event.

The primary extraction well, 299-W19-39, has never exceeded the 480 µg/L RAO for uranium as specified in the ROD, but has never dropped below the 1995 MTCA standard of 48 µg/L. The current concentration of 223 µg/L in the January 2003 sample is a 74% increase over the August 2002 concentration of 134 µg/L and is the second highest concentration at this well after an October 1999 result of 240 µg/L. It is unclear whether this increase represents the start of a trend or is an indication of groundwater variability.

As noted above, extraction well 299-W19-36 was first used as an injection well during Phase I operations. Following conversion to a monitoring well, uranium concentrations increased slowly from 7.7 µg/L at the start of sampling in July 1997 and passed the uranium drinking water standard (DWS) of 48 µg/L by July 1998, at 78 µg/L. A steady climb to 170 µg/L ended in January 2000, and uranium concentrations rapidly increased to 3,110 µg/L by October 2001. Uranium concentrations then declined to 995 µg/L in August 2002 and to 452 µg/L by January 2003. As was the case with technetium, this spike and decline are assumed to be related to the regional flow being re-established in the affected area about the well.

Extraction well 299-W19-43 displayed a similar pattern to that described for well 299-W19-36, but over a shorter timeframe. The well was drilled in the fourth quarter of FY01 and was converted to an extraction well in May 2003. Uranium concentrations at the well increased from 1,230 µg/L in October 2001 to 1,560 µg/L in August 2002, then declined to 1,190 mg/L in January 2003. Following the start of pumping, concentrations declined sharply to the 480 µg/L RAO in July 2003.

B1.8 MONITORING WELLS – URANIUM

Uranium concentration at well 299-W19-20, the monitoring well directly upgradient of 299-W19-39, crudely approximate trends observed for technetium-99. Initially, uranium rose from 128 µg/L in July 1986 to 602 µg/L in March 1989. Following a sampling hiatus, uranium concentrations ranged from 520 to 1,470 µg/L between February 1992 and May 1993; thereafter, uranium levels dropped to 10.5 µg/L in April 1995. By November 1995, a sharp rise had begun that culminated in uranium concentrations of 2,800 µg/L in July 1998 and January 1999. An equally sharp decline followed, ending at 581 µg/L in August 2002 and 459 µg/L in January 2003. The well ran dry in March 2003.

As noted above, well 299-W19-40 monitors contaminant concentrations downgradient of the pump-and-treat system and the primary extraction well, 299-W19-39. This well has never exceeded the 480 µg/L RAO concentration. Initial concentrations measured in late 1995 ranged from 210 to 310 µg/L. By that time, a downward trend was already underway that has since fluctuated between 125 µg/L in December 1996 to 200 µg/L in July 1999. Since then, uranium concentrations have declined to 150 µg/L in August 2002 and 127 µg/L in January 2003.

The uranium trend at well 299-W19-37 has consistently mimicked that of technetium-99. Concentrations began high, reaching 3,920 µg/L of uranium in December 1995 within the first 3 months of well sampling. A sharp decline to 513 µg/L in October 1997 was followed by a slight rebound to 790 µg/L in July 1998. By the next sample, 310 µg/L in January 1999, the 480 µg/L RAO concentration was crossed. Concentrations have remained mostly between 220 and 270 µg/L since then, although the January 2003 concentration was slightly up to 284 µg/L.

At another downgradient well, 299-W19-35, uranium concentrations have remained just above the current DWS of 30 µg/L and often below the original RAO-derived DWS of 48 µg/L in the early 1990s. A few high concentrations at 80 µg/L were detected in February and March 1996, but since July 1999, the concentrations have been below the 1996 DWS of 48 µg/L.

The new well, 299-W19-46, was located adjacent to 299-W19-38, which went dry in June 2001, to continue examining the southern boundary of the primary contaminant plumes. Uranium in well 299-W19-38 initially varied widely between 52 to 250 µg/L in the first 8 months of monitoring, beginning in August 1995. From June 1996 to July 1997, concentrations ranged between 160 to 200 µg/L. Uranium levels then began to rise, reaching 380 µg/L in July 1998 and 368 µg/L in June 1999. Concentrations began to decline, dropping to between 200 and 215 µg/L in the December 1999 through January 2000 timeframe.

Well 299-W19-46 was drilled in November 2002 and sampled at discrete depths to establish a vertical profile of contaminant distribution. The highest uranium concentrations were 131 and 134 µg/L at intervals 3 and 6.4 m (10 and 20.8 ft), respectively, below the top of groundwater. Quarterly sampling since then has declined from 168 µg/L in February 2003 to 105 µg/L in August 2003.

B1.9 CONCLUSIONS

In summary, technetium-99 appears to have declined to below the 9,000 pCi/L RAO at all wells in the 200-UP-1 pump-and treat baseline plume area. Additional sampling is required to confirm whether this is a temporary or long-term trend. The area around wells 299-W19-36 and 299-W19-43 will require additional monitoring and sampling to determine if the declines are related to extraction at the wells removing available contaminants from the groundwater faster than they are desorbing. Concentrations have been the highest at these two wells in past FYs (for technetium-99, 27,200 pCi/L at well 299-W19-36 in November 2000, and 22,400 pCi/L at well 299-W19-43 in August 2002) and appear to have declined sharply in response to pumping. A rebound study examining concentration changes during an episode of non-pumping would provide an indication of how much contamination remains sorbed to the soil.

For uranium, all wells except 299-W19-43 are below the 480 µg/L RAO. At well 299-W19-43, the January 2003 result was 1,190 µg/L and declined further during the influence of pumping to 480 µg/L RAO in July 2003. Additional sampling is required to confirm this downward trend.

B2.0 200-ZP-1 OPERABLE UNIT PUMP-AND-TREAT SYSTEM PERFORMANCE

The pump-and-treat system at the 200-ZP-1 OU is located north and east of Z Plant (234-5Z) (see Figure 1-1 in the main text of this document). The system is designed to contain the high-concentration portions of the primary carbon tetrachloride plume originating from the 216-Z-9 Trench and the 216-Z-1A and 216-Z-18 Cribs and to reduce the concentrations in this plume. Chloroform and trichloroethene are secondary contaminants of concern. This section presents an expanded discussion from that provided in Sections 3.2 through 3.4 in the main text of this document.

B2.1 EXTRACTION SYSTEM PERFORMANCE

Approximately 253.6 million L (67 million gal) of contaminated groundwater were treated in FY03 at an average flow rate of 513 L/min (135.5 gpm). This rate is approximately 10% below the extraction rate goal of 567.8 L/min (150 gpm), due in large part to declines in the groundwater table beneath the 200 West Area. Production rates for the five wells ranged from 34 to 282 L/min (9 to 74.5 gpm). Pumping rates at the extraction wells for the past 8 years are presented in Table B-5 and reveal a general downward trend in the individual wells' overall pumping capacities. In general, the decreasing rates correlate with the wells extracting from a smaller, less productive thickness of aquifer.

Also factoring into the decline was the loss of wells 299-W15-33 and 299-W15-32 for several-month intervals each, in the first and early second quarters of FY03 due to pump and instrumentation problems. From an extraction well production standpoint, the system is considered operational as long as a system low-flow switch, set normally at 378.5 L/min (100 gpm), is not tripped, as the treatment system is not designed to operate at rates much below this level. New extraction wells to replace 299-W15-32 and 299-W15-33 will be brought on-line in FY04 and will be constructed to include larger screened intervals.

Well 299-W15-37, formerly an extraction well, was converted to a monitoring well on January 17, 2001, following more than 3 years of extracting at carbon tetrachloride concentrations below 900 µg/L. Concentrations had gradually increased from a range of 150 to 350 µg/L in the fourth quarter of FY97 to 440 to 540 µg/L in the first quarter of FY01, with an occasional high spike to 1,600 µg/L. This increase showed that the well was drawing the plume toward it, but was inefficient at drawing higher concentration portions of the plume. Following conversion, concentrations of carbon tetrachloride at this well initially rose to 860 µg/L in August 2002 before decreasing to 73 µg/L in March 2003. This indicates there is no loss of control of the RAO plume in the southern-most portion of the baseline area.

Carbon tetrachloride concentrations at well 299-W15-36 have been consistently below the RAO of 2,000 µg/L since May 1998. As shown in Figure 3-8 (main text of this document), continued pumping at this well is drawing a portion of the plume to the southeast, away from the main body of carbon tetrachloride contamination. For these reasons, consideration is being given to converting this to a monitoring well.

B2.2 TREATMENT SYSTEM PERFORMANCE

Treatment of 253.6 million L (67 million gal) of groundwater resulted in the removal of 819.3 kg of carbon tetrachloride in FY03. Since startup of pump-and-treat system operations in August 1994, treatment of almost 2.15 billion L (568 million gal) of groundwater has led to the removal of over 7,668 kg of carbon tetrachloride. The cumulative volume of extracted water versus cumulative mass of contaminants removed is shown in Figure B-4. Table B-6 presents a comparison of treatment volumes and carbon tetrachloride mass remove by FY.

Treatment system performance has improved over FY02. The system's on-line availability calculates the system availability and includes both scheduled and unscheduled outages. The total system availability percentage is a more direct measure of the impact of unscheduled outages on the time available for operations after subtracting time lost to scheduled outages.

For FY03, the extraction system experienced 250 hours of scheduled outages and 168 hours of unscheduled outages. Based on these numbers, the extraction system had an on-line availability of 95.2% (hours operating/total hours in the FY) compared to 93.3% for FY02. The extraction system had a total system availability (hours operating/total hours in FY - scheduled outages) of 98.0% compared to 95.9% for FY02. The last 4 years of operations are summarized in Table B-7

During FY03, the average carbon tetrachloride influent concentration for all extraction wells was 3,212 µg/L, as measured at influent tank T-01. This is a slight increase from 3,144 µg/L in FY02, but less than the 3,600 µg/L concentration reported in FY01. Extraction well concentrations ranged from 900 to 6,200 µg/L, while influent concentrations measured at the influent tank ranged from 2,800 to 4,300 µg/L. The pump in well 299-W15-33 broke down at the end of July 2002 and was replaced at the end of November 2002. Thereafter, it was operated manually through January 1, 2003, due to flow meter problems. Since January 1, the well operated continuously. Well 299-W15-32 was off-line from mid-December 2002 to mid-February 2003 due to a leak detection system problem. Tables B-8 through B-10 summarize concentration changes for each constituent per extraction well for each FY.

The treatment system removal efficiency percentage is calculated on the basis of concentration of carbon tetrachloride in the influent surge tank T-01 versus its concentration at the compliance point (101-V13), downstream of effluent surge tank T-02. At the post-treatment sampling point, both a compliance sample and a field blank sample are taken. Compliance samples were often at concentrations 5 to 20 µg/L above the carbon tetrachloride compliance value of 5 µg/L. This increase is attributed to carbon tetrachloride in the atmosphere being absorbed into the compliance sample. The carbon tetrachloride vapor is present below levels that impact human health. The field blank measures the local ambient carbon tetrachloride in the air and is usually within 1 to 2 µg/L of the compliance sample concentration. Calculating the removal efficiency using the raw post-treatment values alone yielded an average of 99.6% for the year. When the carbon tetrachloride concentration in the field blank is subtracted from the post-treatment sample concentration, an average removal efficiency of 99.95% for the year was calculated.

The efficiency calculation above has been checked by examining the carbon tetrachloride concentration in treated water discharged to the ground at an injection well. For the first 5 months of FY03, samples were taken for field analysis at injection well 299-W18-36. The concentrations were consistently reported as 2 µg/L(U), indicating that the carbon tetrachloride

was present at less than detection concentrations of 2 µg/L. Using 2 µg/L as the post-treatment carbon tetrachloride concentration, a removal efficiency of 99.94% was obtained.

Technetium-99 samples are collected to ascertain if the pump-and-treat system is being affected by radiological contamination. Technetium-99 appears to originate from the 216-T-19 Crib area or the 241-TX/TY Tank Farms, located north and northeast of the 299-W15-34 and 299-W15-35 extraction wells. Technetium-99 is not retained in the treatment system, and none of the values observed anywhere in the system exceed the DWS of 900 pCi/L for technetium-99.

Technetium-99 is acting as a tracer and is detected in injection well samples and at surrounding monitoring wells. Well 299-W15-15, lying north-northeast of the injection wells, has exhibited increasing technetium-99 concentrations, rising from 18 pCi/L in May 1994 to 136 pCi/L in July 2003. This change indicates that injected water is flowing away from the wells and toward monitoring wells. The increase in technetium-99 at this well has accompanied a marked decrease in carbon tetrachloride concentrations from 1,125 µg/L in May 1994, a maximum of 1,850 µg/L in January 1997, to 24 µg/L in July 2003.

B2.3 OVERALL EFFECTIVENESS

The >2,000 µg/L center of the carbon tetrachloride plume for FY03 maintained a similar shape and size to that of FY02. Changes to the 4,000 µg/L plume contour are more noticeable because it has shrunk due to declining concentrations at extraction well 299-W15-33 and monitoring well 299-W15-31A. At well 299-W15-33, the average annual concentration of carbon tetrachloride in FY03, 2,954 µg/L, has declined significantly from the FY02 average of 4,413 µg/L and is attributed to the break in pumping. In comparison, concentrations have increased slightly at well 299-W15-34, from 5,333 µg/L in FY02 to 5,484 µg/L in FY03. In FY02, wells 299-W15-31A, 299-W15-33, 299-W15-34, and 299-W15-1 defined the >4,000 µg/L contour. In FY03, only two wells (299-W15-1 and 299-W15-34) defined that plume. The center of the contaminant mass appears to be drawn toward well 299-W15-34.

Well 299-W15-36 continues to extract significant volumes of groundwater. However, the average concentration for FY03 was 1,097 µg/L, which is 45% below the 2,000 µg/L RAO level. The plume configuration depicted in Figure 3-8 (main text of this document) shows the effect of pumping at 77 L/min (20.3 gpm), stretching the 1,000 µg/L contour to the southeast around the well. It is recommended that this well be converted to a monitoring well and restarted only if sampling shows that the plume is migrating to the east, south of extraction well 299-W15-32. Converting this well is recommended only if the system extraction goal of 567.8 L/min (150 gpm) can be met or exceeded with pumping at replacement wells for 299-W15-32 and 299-W15-33.

Concentrations at the other extraction wells continue to decline slightly (Tables B-8 through B-10). The peak and slow decline in carbon tetrachloride at the other extraction wells implies that the local center of the dissolved mass has arrived at the extraction wells in the past several years. Extraction well 299-W15-32 is located near the northeast corner of the 216-Z-9 Trench, which is regarded as the primary source of the carbon tetrachloride contamination. Its production rate and concentration of carbon tetrachloride have declined dramatically, from >8,000 µg/L in August 1997 to 2,200 µg/L in September 2003. Because of declining extraction rates, a replacement extraction well for 299-W15-32 will be drilled and connected to the treatment system in the spring of FY04.

Over the last few years, the general trend of plume movement, defined by monitoring well sampling, has been to the northeast, away from primary carbon tetrachloride waste disposal sites south and east of the 234-5 Plutonium Finishing Plant (PFP). The overall monitoring well trends are presented in Table B-11, with both FY03 and long-term changes. Well 299-W15-42, drilled in the winter of 2001, was located to determine the presence or absence of high concentrations of carbon tetrachloride around the 234-5 PFP in an area where there were no other wells. Analytical data collected since the well was completed have ranged between 1,200 to 1,500 µg/L for the FY.

A new well, 299-W15-43, was drilled north of well 299-W15-33 in November 2002, near the 216-T-25 Crib. Following initial spikes to 3,300 µg/L during vertical profile sampling, concentrations at this well have remained slightly below the 2,000 µg/L RAO. Another new well, 299-W15-44, located northeast of extraction well 299-W15-34, was drilled and is operated as a *Resource Conservation and Recovery Act of 1976* (RCRA) monitoring well. Sampling for carbon tetrachloride has recently been initiated at that well, and a carbon tetrachloride concentration of 2,900 µg/L was reported in August 2003. Well 299-W15-765, which is another RCRA well near the northwest corner of the 241-TX Tank Farm, was sampled for two quarters in FY03 and yielded carbon tetrachloride concentrations of 3,300 and 3,100 µg/L in June and August 2003, respectively. These data points, combined with results from wells further north, depict a 2,000 µg/L plume located north of the extraction well system. Further study is required to determine the source of the carbon tetrachloride.

No significant changes have been observed for chloroform or trichloroethene in either extraction or monitoring wells. Chloroform concentrations ranged between 6.0 and 31 µg/L in FY03, with the highest concentrations at well 299-W15-34. Trichloroethene concentrations have ranged from 1.9 to 22 µg/L in FY03, with the highest concentrations at well 299-W15-35. All chloroform concentrations were below the DWS of 80 µg/L. Trichloroethene concentrations at wells 299-W15-34 and 299-W15-35 were consistently above the 5 µg/L DWS. At well 299-W15-36, year-long trichloroethene concentrations did not exceed the 5 µg/L DWS. At wells 299-W15-32 and 299-W15-33, only one sample was at or above 5 µg/L.

Monitoring wells between the injection and extraction wells around the 234-5Z PFP have declining carbon tetrachloride concentrations. This is attributed to the radial movement of injected treated water away from the injection wells combining with the easterly regional groundwater flow. The most significant declines have occurred near the injection wells. Carbon tetrachloride at well 299-W15-15 initially ranged between 264 to 543 µg/L in FY88 and peaked at 1,900 µg/L in January 1997. This was followed by a rapid decline and tailing of concentrations to 24 µg/L. Correspondingly, technetium-99 increased from nondetect values of less than 5.5 pCi/L in FY98 to 136 pCi/L in July 2003. A break in groundwater sampling between May 1994 (18.5 pCi/L) and July 1999 (69.4 pCi/L) does not provide a definite indication of the arrival of the technetium-99-bearing injection front, but it is likely to correlate with the pre-January 1997 carbon tetrachloride spike.

Carbon tetrachloride in monitoring wells midway between injection and extraction wells have also declined sharply. At well 299-W15-16, concentrations have declined from 7,800 µg/L in October 1997 to 1,800 µg/L in July 2003. Similarly, at well 299-W15-31A the concentrations have declined from 7,800 µg/L in October 1999 to 3,450 µg/L in July 2003. Technetium-99 concentrations at well 299-W15-16 display no clear increases from radial flow about the

injection wells. Technetium-99 has not been a target analyte at well 299-W15-31A, but it has been added to the FY04 sampling program.

B2.4 SUMMARY

In conclusion, the high-concentration portion of the carbon tetrachloride plume continues to move toward the extraction wells and appears to be hydraulically contained based on contaminant plume maps, contaminant trends in monitoring wells, and hydraulic capture analysis. Contaminant concentrations declined in four of the five extraction wells but increased at well 299-W15-34. This is attributed to the 5-month cessation of pumping at well 299-W15-33 and a low pumping rate when the well resumed operations. The highest concentration portion of the plume (>4,000 µg/L) is being drawn primarily to well 299-W15-34.

Treated water released at the injection wells has diluted and displaced the southern and western portion of the baseline plume, which is being driven to the extraction wells by the increased hydraulic gradient. Contaminant concentrations between injection and extraction wells are declining at variable rates in intermediary monitoring wells.

Shutting off extraction well 299-W15-36 is under consideration because its carbon tetrachloride concentrations are significantly below the RAO of 2,000 µg/L, and it appears to be drawing off a portion of the plume that would otherwise be captured by extraction wells to the north. If the two new extraction wells coming on-line in FY04 are able to make up enough water to meet the overall system requirements of 568 L/min (150 gpm), this change should be implemented.

B3.0 REFERENCES

Procedure POP-30-001, *Effluent Treatment Facility Control Room Rounds*, Fluor Hanford, Inc., Richland, Washington (can be found at web site http://apweb02/wmpdol).

Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq.

Figure B-1. Cumulative Groundwater Treated Versus Technetium-99 Extracted, 200-UP-1 Operable Unit Pump-and-Treat System.

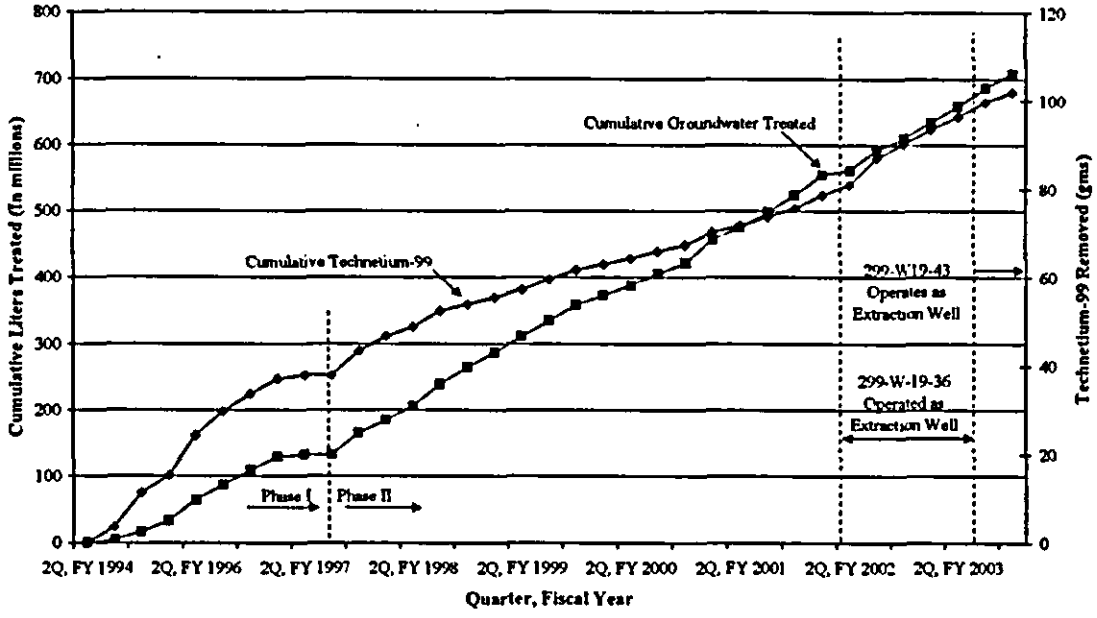

Figure B-2. Cumulative Groundwater Treated Versus Uranium Extracted, 200-UP-1 Operable Unit Pump-and-Treat System.

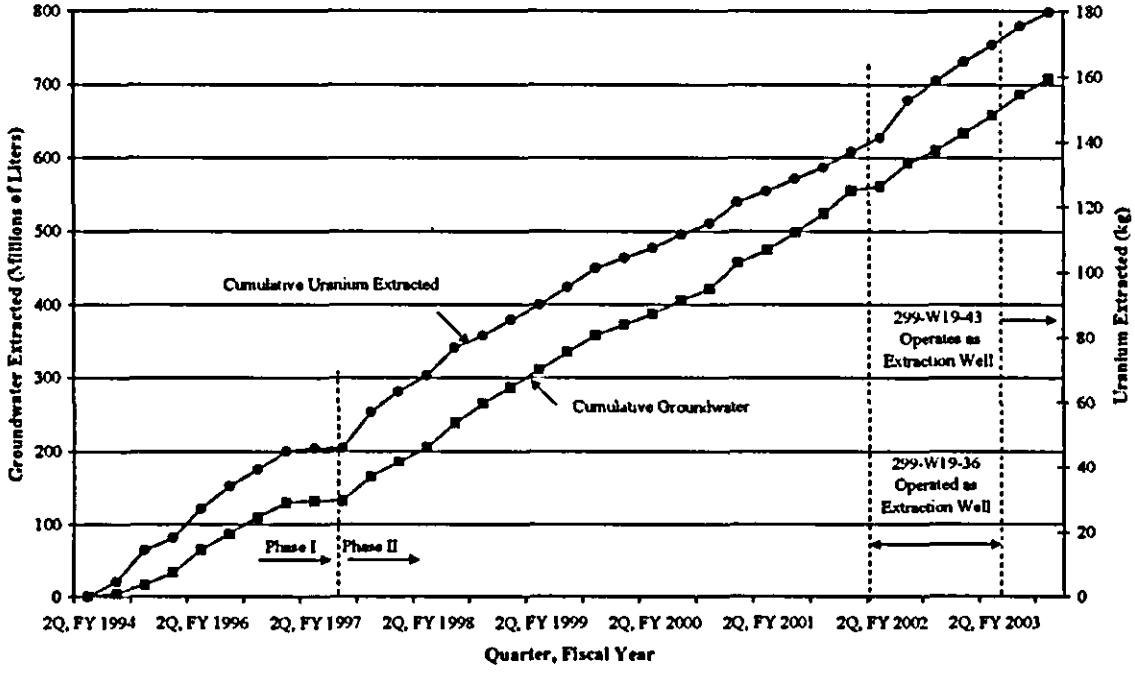

Figure B-3. Cumulative Groundwater Treated Versus Carbon Tetrachloride and Nitrate Extracted, 200-UP-1 Operable Unit Pump-and-Treat System.

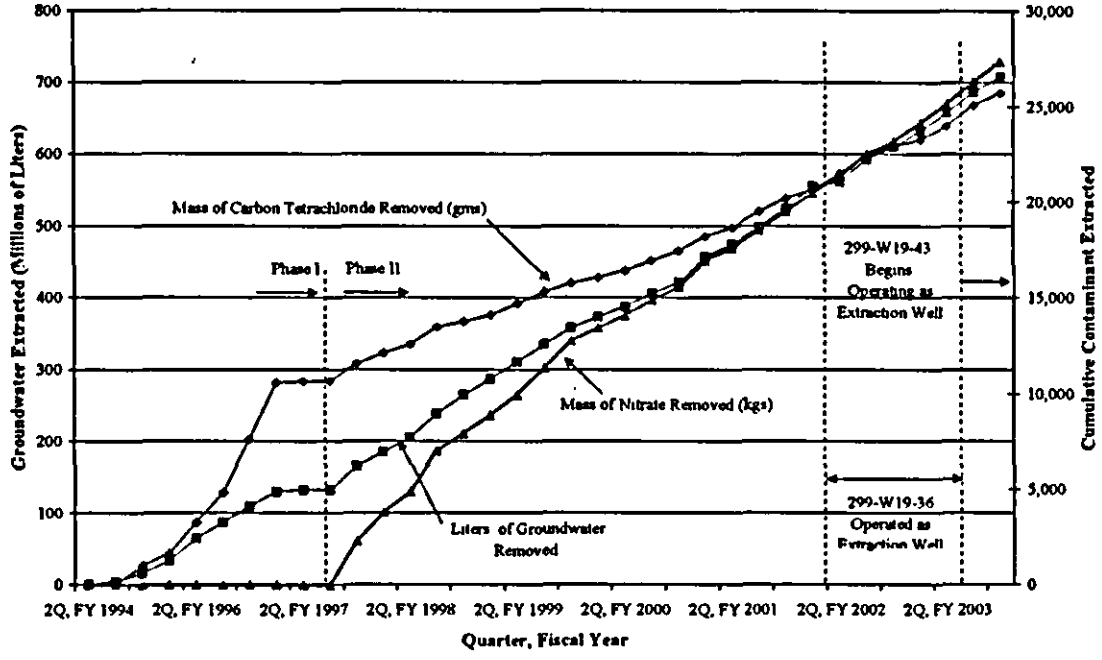

Figure B-4. Cumulative Groundwater Treated Versus Carbon Tetrachloride Extracted, 200-ZP-1 Operable Unit Pump-and-Treat System.

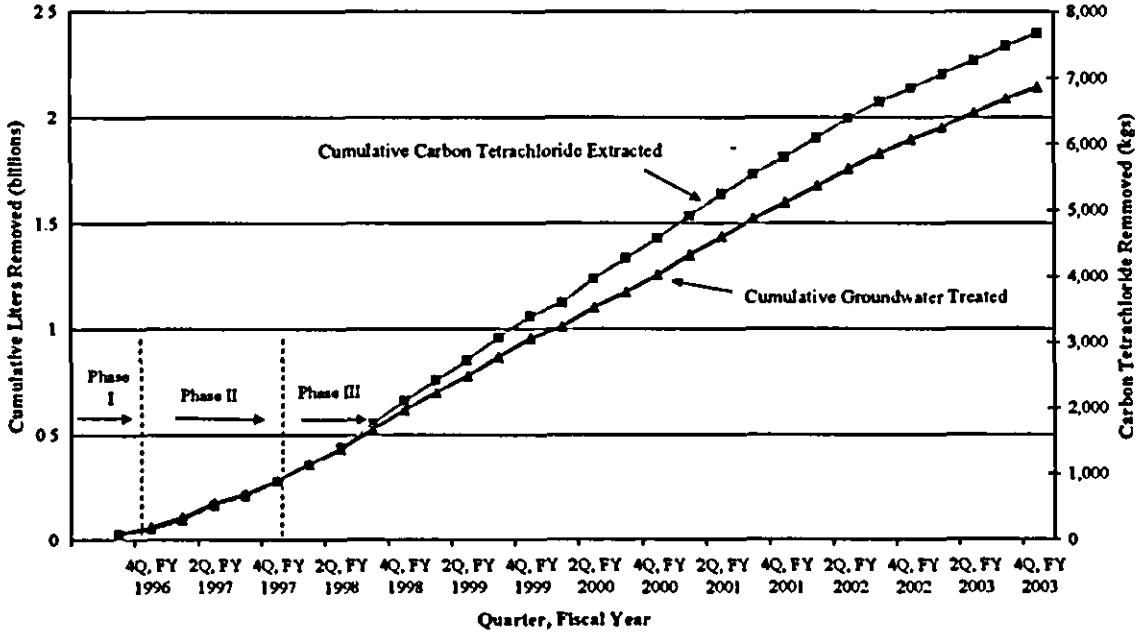

Table B-1. Treatment System Availability of 200-UP-1 Operable Unit Pump-and-Treat System, Fiscal Years 2000 to 2003.

Parameter	FY00	FY01	FY02	FY03
Total hours in FY	8,784	8,760	8,760	8,760
Scheduled outage hours	1,270[a]	246	501	231
Unscheduled outage hours	0	187	446.5	45
Total time available (total hours - scheduled outages)	7,527	8,514	8,259	8,529
Total time on-line (total hours – [scheduled + unscheduled outages])	7,527	8,327	7,812.5	8,484
System on-line availability (total time on-line/total hours)	85.7%	95.1%	89.2%	96.8%
Total system availability (total time available/total time on-line)	100%	97.8%	94.6%	99.5%

[a] System shut down for approximately 31 days (December 27, 1999, through January 26, 2000) in anticipation of year 2000 rollover problems and resolution of Federal funding issues.
FY = fiscal year

Table B-2. 200-UP-1 Groundwater Pump-and-Treat Summary of Operations, Fiscal Year 1998 to Fiscal Year 2003.

Activity	FY98	FY99	FY00	FY01	FY02	FY03
System on-line availability	85.2%	97.5%	85.7%	95.1%	89.2%	96.8%
System availability	--	--	100.0%	97.8%	94.3%	99.4%
Annual average pumping rate, L	190	182	180	183	197	178.3
Average well head technetium-99 concentration, pCi/L	2,050	1,400	1,475	1,395	2,502	1,980
Average well head uranium concentration, µg/L	265.5	208	214	160	282	200
Average well head carbon tetrachloride concentration, µg/L	24	18	25	28	24	27.4
Average well head nitrate concentration, mg/L	63.4	47.2	44	38	36	44.7
Total volume treated at ETF, L	100,700,000	93,500,000	63,229,380	102,475,318	85,886,455	98,343,000
Technetium-99 removed, g (Ci)	10.54 (0.18)	7.8 (0.13)	5.6 (0.10)	8.4 (0.14)	14.5 (0.25)	11.8 (0.2)
Uranium removed, kg	23.6	20.7	13.6	17.1	26.4	21.2
Carbon tetrachloride removed, kg	2.2	2.0	1.7	2.7	2.7	2.8
Carbon tetrachloride lost in transit, kg	8.9	9.3	5.7	6.6	7.6	5.8
Nitrate removed, kg	5,650	4,859	2,807	3,924	3,686	4,158
Powder waste produced, number of 208-L (55-gal) drums	425	474	313	343	426	461
Sludge/other waste produced, number of 208-L (55-gal) drums	353	236	13	44	9	9
Contact waste produced, boxed, m^3	14.5	7.2	10.9	30.6	27.6	18

ETF = Effluent Treatment Facility
FY = fiscal year

Table B-3. Quantity of Treated Groundwater and Contaminant Mass Removed Since Initiation of 200-UP-1 Pump-and-Treat Operations.

Reporting Period	Liters Treated	Mass Tc-99 Removed (g)	Mass Total U Removed (g)	Mass Carbon Tet. Removed (g)	Mass Nitrate Removed (kg)
Mar 1994 to Sept. 1996	108,629,387	33.6	39,232	7,590	NA
FY97	55,382,081	9.8	17,570	3,941	2,260
FY98	100,067,035	10.5	23,630	2,235	5,650
FY99	93,471,260	7.8	20,700	2,002	4,859
FY00	63,229,380	5.6	13,640	1,659	2,807
FY01	102,475,318	8.4	17,128	2,744	3,924
FY02	85,886,455	14.5	26,420	2,747	3,686
FY03	98, 343,000	11.8	21,174	2,799	4,158
Totals	**707,483,916**	**102.0**	**179,494**	**25,717**	**27,344**

FY = fiscal year

Table B-4. Summary by Fiscal Year and Fiscal Year 2003 Quarters of Technetium-99, Uranium, and Carbon Tetrachloride Concentrations Measured at Active 200-UP-1 Wells. (2 sheets)

Well ID	Well Name	FY98 Avg.	FY99 Avg.	FY00[a] Avg.	FY01 Avg.	FY02 Avg.	FY03 Concentration	Annual Comparison[b]	1st Qtr. 2003	2nd Qtr. 2003	3rd Qtr. 2003	4th Qtr. 2003	Quarterly Comparison[c]
Technetium-99 (pCi/L)													
A4949	299-W19-20	4,780	6,218	7,330	5,320	1,480	838	Decreasing	--	838	--	--	NA
A9517	299-W19-34A	250	232	179	158	131	NA	NA	--	--	--	--	NA
A9515	299-W19-35	442	460	515	563	518	795	Increasing	--	795	--	--	NA
A2461	299-W19-36	1,416	4,280	19,350[d]	22,125[d]	13,015[d]	4,600	Decreasing	--	4,600	--	--	NA
B2465	299-W19-37	3,346	2,643	1,068	600	586	622[e]	Stable	436	--		808	Increasing
B2460	299-W19-39	1,310		1,540	1,310	1,216	952	Decreasing	--	952	--	--	NA
B2464	299-W19-40	343	291	356	324	224	170	Decreasing	--	170	--	--	NA
C3381	299-W19-43	--	--	--	--	18,575[d]	10,795[e]	Decreasing	--	18,200[d]	--	3,390	Decreasing
C3598	299-W19-46	--	--	--	--	--	157[e]	NA	163	154	174	139	Variable
Uranium (µg/L)													
A4949	299-W19-20	2,277[d]	2,600[d]	2,000[d]	979[d]	687[d]	459	Decreasing	--	459	--	--	NA
A9517	299-W19-34A	2.6	2.1	2	1	1.2	NA	NA	--	--	--	--	NA
A9515	299-W19-35	47	45	37	41	42	42.7	Stable	--	42.7	--	--	NA
A2461	299-W19-36	41	92	160	2,005[d]	1,724[d]	453	Decreasing	--	453	--	--	NA
B2465	299-W19-37	600[d]	307	195	272	262	266[e]	Stable	249	--	-	284	Stable
B2460	299-W19-39	233		240	149	137	223	Increasing	--	223	--	--	NA
B2464	299-W19-40	170	198	160	159	153	127	Stable	--	127	--	--	NA
C3394	299-W19-43	--	--	--	--	1,560[d]	835	Decreasing	--	1,190[d]	--	480	Decreasing
C3958	299-W19-96	--	--	--	--	--	142[e]	NA	131	168	164	105	Variable

Table B-4. Summary by Fiscal Year and Fiscal Year 2003 Quarters of Technetium-99, Uranium, and Carbon Tetrachloride Concentrations Measured at Active 200-UP-1 Wells. (2 sheets)

Well ID	Well Name	FY98 Avg.	FY99 Avg.	FY00[a] Avg.	FY01 Avg.	FY02 Avg.	FY03 Concentration	Annual Comparison[b]	1st Qtr. 2003	2nd Qtr. 2003	3rd Qtr. 2003	4th Qtr. 2003	Quarterly Comparison[c]
Carbon Tetrachloride (µg/L)													
A4949	299-W19-20	116	48	48	47	34	34	Stable	--	34	--	--	NA
A9517	299-W19-34A	148	177	185	131	139	NA	NA	--	--	--	--	NA
A9515	299-W19-35	202	209	205	127	138	94	Decreasing	--	94	--	--	NA
A2461	299-W19-36	2(U)	87	210	293	214	270	Increasing	--	270	--	--	NA
B2465	299-W19-37	39	97	98	77	78	73[e]	Stable	68	--		79	Stable
B2460	299-W19-39	76	150	100	82	91	72	Decreasing	--	72	--	--	NA
B2464	299-W19-40	80	86	71	46	40	24	Decreasing	--	24	--	--	NA
C3381	299-W19-43	--	--	--	--	109	80[e]	Decreasing	--	79	--	81	Stable
C3958	299-W19-46	--	--	--	--	--	81[e]	NA	98	80	77	68	Variable

[a] Third and fourth quarter data from FY00 were not included because waste control issues precluded sampling of all 200-UP-1 wells.
[b] Percent difference between FY03 and FY02and is calculated as follows: (FY03 - FY02)/FY02 x 100%. Wells are considered stable if there is less than a 20% change in concentration between FY02 and FY03.
[c] Quarterly comparisons are based on a visual inspection of the data.
[d] Concentrations or activities above the remedial action objective of 9,000 pCi/L or the remedial action objective of 480 µg/L for uranium.
[e] Concentration averaged for the year.
FY = fiscal year
ID = identification
NA = not applicable

Table B-5. Average Annual Pumping Rates (L/min) at Individual 200-ZP-1 Extraction Wells By Fiscal Year.

Well ID	FY97	FY98	FY99	FY00	FY01	FY02	FY03
299-W15-33	111	66	64	36	55	42	43
299-W15-34	160	101	88	82	93	85	77
299-W15-35	303	301	325	245	307	301	282
299-W15-32	97	81	67	114	40	34	34
299-W15-36	62	112	67	92	131	106	77
299-W15-37	62	63	60	56	63	--	--
Annual sum	795	724	671	625	689	568	513

FY = fiscal year

Table B-6. Quantity of Treated Groundwater and Contaminant Mass Removed Since Initiation of 200-UP-1 Pump-and-Treat Operations.

Reporting Period	Liters Treated	Mass Carbon Tet. Removed (g)
August 1994 to July 1996	26,676,000	75.9
August to September 1996	33,232,327	61.0
FY97	218,800,017	750.3
FY98	336,162,100	1,212.2
FY99	340,781,036	1,287.3
FY00	300,403,641	1,183.3
FY01	338,846,428	1,226.3
FY02	301,282,482	1,052.7
FY03	253,601,656	819.3
Totals	2,149,785,687	7,668.3

FY = fiscal year

Table B-7. Treatment System Availability of 200-ZP-1 Operable Unit Pump-and-Treat System, Fiscal Years 2000 to 2003.

Parameter	FY00	FY01	FY02	FY03
Total hours in FY	8,784	8,760	8,760	8,760
Scheduled outage hours	1,218[a]	76	236	250
Unscheduled outage hours	477	176	352.5	168
Total time available (total hours - scheduled outages)	7,566	8,684	8,524	8,510
Total time on-line (total hours – [scheduled + unscheduled outages])	7,089	8,508	8,171.5	8,342
System on-line availability, % (total time on-line/total hours)	80.7	97.1	93.3	95.2
Total system availability, % (total time on-line/total time available)	93.7	97.8	95.9	98.0

[a] Includes downtime due to year 2000 rollover (December 6. 1999, through January 3, 2000) and Federal budget resolution.
FY = fiscal year

Table B-8. Average Carbon Tetrachloride Concentration for Each of the Extraction Well and Influent Tank at 200-ZP-1 Operable Unit During Fiscal Years 1997 to 2003.

Well Name[a]	FY03 Min. Value (µg/L)	FY03 Max. Value (µg/L)	Mean Concentration Carbon Tetrachloride (µg/L)							Mean Flow Rate (L/min)	Annual Comparison[b]
			FY97	FY98	FY99	FY00	FY01	FY02	FY03		
299-W15-33	1,900	5,300[c]	5,058	6,000	6,218	5,956	4,865	4,413	3,308	43	Decreasing
299-W15-34	2800[c]	3,200	2,900	3,770	4,700	5,517	5,355	5,333	5,355	77	Stable
299-W15-35	2,200	4,000	3,351	3,660	3,858	3,842	3,413	3,344	3,233	282	Stable
299-W15-32	1,600	4,100	7,120	6,560	5,023	4,224	3,255	2,778	2,556	34	Stable
299-W15-36	770	1,800	2,820	2,040	1,697	1,779	1,377	1,195	1,097	77	Stable
Influent tank (T-01)	2,800	4,300	3,270	3,530	3,788	4,041	3,600	3,356	3,212	--	Stable

[a] Wells are listed from north to south.
[b] Annual comparison is the percent difference between FY01 and FY00 (or two most recent years) and is calculated by the following equation: (FY03 - FY02)/FY02 x 100%. Wells are considered stable if there is less than a 20% change in concentration from FY02 to FY03.
[c] Maximum reported value 5,300 µg/L in January 29, 2003, was dropped due to anomalous values at wells 299-W15-33 and 299-W15-34.
FY = fiscal year

Table B-9. Average Chloroform Concentrations for Each of the Extraction Wells and the Influent Tank at 200-ZP-1 Operable Unit During Fiscal Years 1998 to 2003.

Well Name[a]	FY03 Min. Value (µg/L)	FY03 Max. Value (µg/L)	Mean Concentration Chloroform (µg/L)						Annual Comparison[b]
			FY98	FY99	FY00	FY01	FY02	FY03	
299-W15-33	11	25	26.6	25.7	24.1	25.9	18.2	14.7	Decreasing
299-W15-34	12	31	14.9	18.9	21.7	23.4	23.4	23.8	Stable
299-W15-35	16	22	16.7	18.7	18.2	18.6	16.6	17.2	Stable
299-W15-32	18	24	39.9	32.4	26.7	26.8	20.2	20.3	Stable
299-W15-36	18	26	24	22.5	21.9	23.9	20.1	20.2	Stable
Influent tank (T-01)	16	23	20.5	20	21.1	18.3	18.6	18.8	Stable

[a] Wells are listed from north to south.
[b] Annual comparison is the percent difference between FY02 and FY01 (or two most recent years) and is calculated by the following equation: (FY02 - FY01)/FY01 x 100%. Wells are considered stable if there is less than a 20% change in concentration from FY01 to FY02.
FY = fiscal year

Table B-10. Average Trichloroethene Concentrations for Each of the Extraction Wells and the Influent Tank at 200-ZP-1 Operable Unit During Fiscal Years 1998 to 2003.

Well Name[a]	FY03 Min. Value (µg/L)	FY03 Max. Value (µg/L)	Mean Concentration Trichloroethene (µg/L)						Annual Comparison[b]
			FY98	FY99	FY00	FY01	FY02	FY03	
299-W15-33	2	12	9.7	8.1	6.3	4.6	4.1	3.7	Stable
299-W15-34	2.2	18	11.3	13.5	13.2	11.4	11.2	11.7	Stable
299-W15-35	8.5	14	5.4	8.3	8.5	9	9.1	10.1	Stable
299-W15-32	3.2	5.6	5.4	5.8	4.9	4.5	4.2	4.6	Stable
299-W15-36	2	3.5	9	6.1	5	3.5	2.9	2.6	Stable
Influent tank (T-01)	7.2	12	6.6	7.8	8.5	7.4	7.9	8.7	Stable

[a] Wells are listed from north to south.
[b] Annual comparison is the percent difference between FY02 and FY01 (or two most recent years) and is calculated by the following equation: (FY02 - FY01)/FY01 x 100%. Wells are considered stable if there is less than a 20% change in concentration from FY01 to FY02.
FY = fiscal year

Table B-11. Summary of Constituent Concentrations Measured at 200-ZP-1 Operable Unit Monitoring Wells. (4 sheets)

Well ID	Well Name	FY98 Avg.	FY99 Avg.	FY00[a] Avg.	FY01 Avg.	FY02 Avg.	FY03 Concentration	Annual Comparison[b]	1st Qtr. 2003	2nd Qtr. 2003	3rd Qtr. 2003	4th Qtr. 2003	Quarterly Comparison[c]
Carbon Tetrachloride (µg/L)													
A4915	299-W14-9	36	43	24	38	51	NA	NA	--	--	--	--	NA
A7348	299-W15-1	3,917	6,100	6,367	5,675	5,800	4,300	Decreasing	--	4,400	--	4,200	
A5476	299-W15-7	3,364	3,900	4,233	3,525	3,138	2,000	Decreasing	--	2,900	--	1,100	
A5474	299-W15-11	2,442	2,725	4,400	4,425	3,975	3,100	Decreasing	--	3,100	--	3,100	
A4919	299-W15-15	661	364	126	67	37	24.5	Decreasing	--	25	--	24	
A4920	299-W15-16	5,918	5,650	4,033	2,875	1,075	2,129	Increasing	2,036	2,550	--	1,800	
A5476	299-W15-17	--	--	--	--	--	13.5	NA	--	15	--	12	
A4922	299-W15-18	1,706	1,500	825	--	--	NA	NA	--	--	--	--	NA
B2410	299-W15-30	--	--	6,600	4,300	2,700	NA	NA	--	--	--	--	NA
B2471	299-W15-31A	5,488	6,525	6,933	4,838	5,000	4,237	Stable	4,962	4,300	--	3,450	
B2754	299-W15-38	2,820	3,238	3,333	2,675	2,275	2,100	Stable	--	2,100	--	--	NA
B2477	299-W15-39	1,212	1,200	1,577	743	483	650	Increasing	--	650	--	--	NA
C3803	299-W15-42	--	--	--	--	1,480	1,367	Stable	1,500	1,200	1,400	--	
C3955	299-W15-43	--	--	--	--	--	2,075	NA	2,700	1,900	2,000	1,700	
C3956	299-W15-44	--	--	--	--	--	2,900	NA	--	--	--	2,900	NA
A5481	299-W18-1	1,440	1,375	923	398	183	110	Decreasing	--	110	--	--	NA
A4933	299-W18-21	172.2	185	87	27	16	13.5	Stable	--	14	--	13	
A4936	299-W18-24	1,363	1,250	843	555	32	NA	NA	--	--	--	--	NA
A4939	299-W18-27	301	374	263	104	143	4.6	Decreasing	--	4.6	--	--	NA
A4942	299-W18-30	568	499	317	210	185	120	Decreasing	--	120	--	--	NA
A7522	299-W18-4	--	265	113	36	17	NA	NA	--	--	--	--	NA
A5151	699-39-79	--	2(U)	2(U)	--	2(U)	0.15	Increasing	--	0.15	--	--	NA

Table B-11. Summary of Constituent Concentrations Measured at 200-ZP-1 Operable Unit Monitoring Wells. (4 sheets)

Well ID	Well Name	FY98 Avg.	FY99 Avg.	FY00[a] Avg.	FY01 Avg.	FY02 Avg.	FY03 Concentration	Annual Comparison[b]	1st Qtr. 2003	2nd Qtr. 2003	3rd Qtr. 2003	4th Qtr. 2003	Quarterly Comparison[c]
A5202	699-47-60	--	2(U)	2(U)	--	1.4(U)	0.15	Increasing	--	0.15	--	--	NA
A8868	699-55-60A	--	--	0.23(U)	--	2(U)	0.15	Increasing	--	0.15	--	--	NA
Chloroform (µg/L)													
A4915	299-W14-9	73	127	110	115	61	NA	NA	--		--		NA
A7348	299-W15-1	26	28	32	28	28	22	Decreasing	--	23	--	21	
A5476	299-W15-7	30	32	29	20	22	18	Stable	--	20	--	16	
A5474	299-W15-11	30	18	26	21	19	14.5	Decreasing	--	15	--	14	
A4919	299-W15-15	3	2(U)	1.5	1	0.27	0.22	Stable	--	0.24	--	0.21	
A4920	299-W15-16	37	31	23	16	15	10.6	Decreasing	12	11.5	--	9.7	
A5476	299-W15-17	--	--	--	--	--	2	NA	--	2.2	--	1.95	
A4922	299-W15-18	14	7.3	4	--	--	NA	NA	--		--	--	NA
B2410	299-W15-30	--	--	34	21	13	NA	NA	--		--	--	NA
B2471	299-W15-31A	35	38	37	34	49	24	Decreasing	30	25	--	17.5	
B2754	299-W15-38	24	26	23	20	19	18	Stable	--	18	--	--	NA
B2477	299-W15-39	15	15	18	14	14	12	Stable	--	12	--	--	NA
C3803	299-W15-42	--	--	--	--	28	16	Decreasing	19	15	14.5	--	
C3955	299-W15-43	--	--	--	--	--	15	NA	27	12	12	8.9	
C3956	299-W15-44	--	--	--	--	--	17	NA	--	--	--	17	NA
A5481	299-W18-1	14	11	5	2(U)	1.2	1	Stable	--	1	--	--	NA
A4933	299-W18-21	2(U)	2(U)	1.1		0.22	0.12	Increasing	--	0.07(U)	--	0.16	
A4936	299-W18-24	16	11	8	3	2(U)	NA	NA	--	--	--	--	NA
A4939	299-W18-27	--	--	--	2(U)	1.2	0.8	Decreasing	--	0.8	--	--	NA
A4942	299-W18-30	14	13	11	10	12	11	Stable	--	11	--	--	NA

Table B-11. Summary of Constituent Concentrations Measured at 200-ZP-1 Operable Unit Monitoring Wells. (4 sheets)

Well ID	Well Name	FY98 Avg.	FY99 Avg.	FY00[a] Avg.	FY01 Avg.	FY02 Avg.	FY03 Concentration	Annual Comparison[b]	1st Qtr. 2003	2nd Qtr. 2003	3rd Qtr. 2003	4th Qtr. 2003	Quarterly Comparison[c]
A7522	299-W18-4	--	93	17	18	12	NA	NA	--	--	--	--	NA
A5151	699-39-79	--	2(U)	2(U)	--	2(U)	0.07(U)	Stable	--	0.07(U)	--	--	NA
A5202	699-47-60	--	2(U)	2(U)	--	2(U)	0.07(U)	Stable	--	0.07(U)	--	--	NA
A8868	699-55-60A	--	--	0.23(U)	--	2(U)	0.07(U)	Stable	--	0.07(U)	--	--	NA
Trichloroethene (µg/L)													
A4915	299-W14-9	4	5.4	4	4	4.3	NA	NA	--		--	--	NA
A7348	299-W15-1	19	16	14	10	2.8	5.5	Increasing	--	5.6	--	5.5	
A5476	299-W15-7	21	29	28	16	12.3	8	Decreasing	--	8.7	--	7.4	
A5474	299-W15-11		4	5	5	4	3.2	Stable	--	3.2	--	3.2	
A4919	299-W15-15	4	2(U)	3	2(U)	1.7(U)	0.16(U)	Stable	--	0.16(U)	--	0.16(U)	
A4920	299-W15-16	7	6	3	3	2.2	1.8	Stable	2	2	--	1.5	
A5476	299-W15-17	--	--	--	--	--	1.1	NA	--	1.3	--	1	
A4922	299-W15-18	2(U)	2(U)	3	--	--	NA	NA	--	--	--	--	NA
B2410	299-W15-30	--	--	5	3	2(U)	NA	NA	--	--	--	--	NA
B2471	299-W15-31A	6	7	6	5	4.6	3.3	Decreasing	4	3.3	--	2.7	
B2754	299-W15-38	3	4	5	5	4.6	4.2	Stable	--	4.2	--	--	NA
B2477	299-W15-39	2(U)	2.1	3	2(U)	2(U)	2	Increasing	--	2	--	--	NA
C3803	299-W15-42	--	--	--	--	2.4	2.5	Stable	2.7	2.3	2.5	--	
C3955	299-W15-43	--	--	--	--	--	3.8	NA	0.16(U)	5.1	5.2	4.7	
C3956	299-W15-44	--	--	--	--	--	15	NA	--	--	--	15	NA
A5481	299-W18-1	2(U)	2(U)	1.5	2(U)	2(U)	0.16(U)	Stable	--	0.16(U)	--	--	NA
A4933	299-W18-21	2(U)	2(U)	0.8	1.1(U)	1.2(U)	0.16(U)	Stable	--	0.16(U)	--	0.16(U)	
A4936	299-W18-24	2(U)	2(U)	4	1	1.2(U)	NA	NA	--	--	--	--	NA

Table B-11. Summary of Constituent Concentrations Measured at 200-ZP-1 Operable Unit Monitoring Wells. (4 sheets)

Well ID	Well Name	FY98 Avg.	FY99 Avg.	FY00[a] Avg.	FY01 Avg.	FY02 Avg.	FY03 Concentration	Annual Comparison[b]	1st Qtr. 2003	2nd Qtr. 2003	3rd Qtr. 2003	4th Qtr. 2003	Quarterly Comparison[c]
A4939	299-W18-27	2(U)	2(U)	2(U)	2(U)	1.1(U)	0.16(U)	Stable	--	0.16(U)	--	--	NA
A4942	299-W18-30	2(U)	2(U)	1.7	1	2(U)	0.7	Increasing	--	0.7	--	--	NA
A7522	299-W18-4	--	2(U)	2(U)	2(U)	2(U)	NA	NA	--		--	--	NA
A5151	699-39-79	--	2(U)	2(U)	--	2(U)	0.16(U)	Stable	--	0.16(U)	--	--	NA
A5202	699-47-60	--	2(U)	2(U)	--	--	0.16(U)	Stable	--	0.16(U)	--	--	NA
A8868	699-55-60A	--	--	0.23(U)	--	--	0.16(U)	Stable	--	0.16(U)	--	--	NA

[a] Annual comparison is the percent difference between FY02 and FY01 (or two most recent years) and is calculated by the following equation: (FY02 - FY01)/FY01 x 100%. Wells are considered stable if there is less than a 20% change in concentration from FY01 to FY02.
[b] Quarterly comparisons are based on a visual inspection of the data.
[c] No comparison possible.
-- = Data not available.
FY = fiscal year
ID = identification
NA = not available

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APPENDIX C

HYDROGRAPHS AND AQUIFER RESPONSE

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CONTENTS

FIGURES

TABLES

TERMS

amsl	above mean sea level
FY	fiscal year
gpm	gallons per minute
OU	operable unit

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APPENDIX C

HYDROGRAPHS AND AQUIFER RESPONSE

The hydraulic responses of the aquifer at both 200-UP-1 and 200-ZP-1 Operable Units (OUs) are measured through the use of water-level data, which are collected by both direct tape measurement and automated data logger recording of in-well pressure transducers. The water-level data are used to assess the effects of the extraction wells on the aquifer through the following methods:

- Generation of water table maps to compare changes in the water table surface over time
- Calculation of drawdown at monitoring wells, which establishes the radius of influence and zone of capture of contaminants
- Numerical modeling, which when combined with contaminant data yields contaminant movement and behavior data.

Changes in groundwater levels result from the cessation of discharges to waste sites at the 200 West Area and a slow return to pre-Hanford Operations conditions. The 216-U-10 Pond and its contributing ditches received an estimated 165 billion L (43.6 billion gal) of wastewater between 1944 and 1965. Beginning in 1984 with the shutdown of the 216-U-10 Pond and continuing through activation of the Treated Effluent Disposal Facility in 1995, other waste streams ceased discharging to the soil column. Past that date, one sanitary tile field remained active near each pump-and-treat site. The 2607-Z tile field was shut down in 1999, while the 2607-W-5 tile field remains active to the present. Waste volumes disposed at this site are unknown but are assumed to be low and of no impact to the pump-and-treat systems.

Drawdown data are presented here but are used primarily with numerical modeling, as discussed in Appendix E. The data are gathered when extraction well pumps are shut down or restarted. The water-level changes from the rebound after shutdown or declines at restart of the pump are captured at both extraction and nearby monitoring wells.

C1.0 200-UP-1 OPERABLE UNIT AQUIFER RESPONSE

This section discusses the response of the aquifer to the operation of the 200-UP-1 OU pump-and-treat activity during fiscal year 2003 (FY03) with data gathered from the existing well network. This response is discussed in terms of the hydraulic and contaminant changes observed during FY03. The hydraulic monitoring data are used with groundwater modeling, which is reported in Appendix E.

C1.1 HYDRAULIC MONITORING

The water-level monitoring network, first installed in August 1995 at the 200-UP-1 OU, has undergone several revisions. The continued decline in the regional water table has resulted in certain monitoring wells becoming unserviceable (denoted by an "X" in Figure C-1). During FY03, the pump-and-treat configuration underwent several changes. In mid-May 2003, monitoring well 299-W19-43 was configured as an extraction well using parts and equipment

from well 299-W19-36, which was converted to a monitoring well. By the end of FY03, well 299-W19-36 was equipped with an extraction pump and connected to the pipeline, and will be used in FY04 for backup or increased pumping capacity. This reconfiguration was performed to meet the goal of a 189.3 L/min (50 gallons per minute [gpm]) pumping rate for the extraction system. The reconfiguration caused some gaps in the water-level monitoring data as transducers were removed while the wells were being reconfigured. As of the end of FY03, the network records groundwater elevation data from eight wells, including the three extraction wells, on an hourly basis. The hydrographs of the three extraction wells and several monitoring wells are presented in Figure C-2. The hydrograph for well 299-W19-39 suggests a malfunction of the transducer in September 2003, as no changes in pumping rate were observed.

Based on the water-level data collected during FY03, it appears that the unconfined aquifer underlying the 200-UP-1 OU declined at a rate of 0.38 m/yr (1.25 ft/yr) (Figure C-3), essentially the same rates as FY01 (0.4 m/yr [1.31 ft/yr]) and FY02 (0.36 m/yr [1.18 ft/yr]). The rate of decline is based on data from wells 299-W19-35 and 299-W19-37, which are least affected by the extraction well activities.

A comparison has been made by comparing water levels at two wells: well 699-35-70A (located approximately 1,080 m [3,543.5 ft] southeast of extraction well 299-W19-39) and well 699-38-70 (located approximately 650 m [2,132.7 ft] east of well 299-W19-39) (see Figure C-4). Well 699-35-70 has been actively monitored since August 1951, at which time the water level was 125.5 m (411.8 ft) above mean sea level (amsl). The water level climbed to 140 m (459.3 ft) by April 1969, which is a 14.5 m (47.6 ft) increase, and then peaked at 140.15 m (459.8 ft) in December 1984. Water levels in well 699-35-70A then began a slow decline to 134.04 m (439.8 ft) amsl in September 2003. This is an elevation difference of 8.5 m (28 ft) between current and near pre-Hanford levels. Well 699-38-70 (Figure C-4) has followed well 699-35-70A in having near-identical water levels. Water-level data at both wells suggest significant declines in the foreseeable future for groundwater levels and wells in the 200-UP-1 OU baseline plume area.

The decline in the water table continues to affect the 200-UP-1 OU monitoring well network through the loss of water-level monitoring wells. During the last 3 years, wells 299-W19-20, 299-W19-38, and 299-W19-40 were lost for water-level monitoring because the water levels in these wells dropped below levels that would allow transducer usage. Well 299-W19-20 is impacted by pumping at extraction well 299-W19-39 and might otherwise intersect the water table. A nearby replacement well, "K," identified in the *Sampling and Analysis Plan for the 200-UP-1 Groundwater Monitoring Well Network* (DOE-RL 2002), is planned in FY04. Well 299-W19-40 can still be sampled by pump and is estimated to have a 4-year service life at the current water level rate of decline. However, water levels at this well have dropped below the transducer.

The loss of well 299-W19-38 left the monitoring network without water-level coverage in the south or southwest portions of the contaminant plume. During FY03, well 299-W19-46 was drilled and installed to fill in the monitoring well gap in the southern portion of the plume. Water-level monitoring equipment was not installed in well 299-W19-46 until the end of FY03, therefore, no data from that well appear in this report.

Figure C-1 shows the change in the water table from 1995 to 2003. The direction of the regional groundwater flow has changed at 200-UP-1 from west/northwest to east/southeast in FY95, to nearly west to east in FY03. Water levels have declined 4 m (13.1 ft) or more at most points in the baseline plume.

C1.2 DRAWDOWN

As explained above, three different wells were employed to extract groundwater for treatment during FY03. Drawdown at each well was calculated from water-level recovery data collected after shutdown or restart of the extraction well pump. A separate period was selected for each well in which the other two wells were either not pumping or were in a stable pumping state. Drawdown for well 299-W19-39 was calculated during shutdown and restart from May 24 to 26, 2003; for well 299-W19-36 from January 6 to 9, 2003; and for well 299-W19-43 from July 9 to 16, 2003.

To calculate the drawdown caused by an extraction well, water-level data were adjusted to account for barometric effects and the regional water-level decline. The technique used to account for the barometric effects and water-level decline is described in *Fiscal Year 1998 Annual Summary Report for the 200-UP-1, 200-ZP-1, and 100-NR-2 Pump-and-Treat Operations and Operable Units* (DOE-RL 1999).

Due to reconfiguration of the extraction system during FY03 the drawdown calculations are not readily comparable to results from previous years. Extraction well 299-W19-39 pumped at the greatest rate (approximately 140 L/min [37 gpm]) with a drawdown of 7.2 m (23.6 ft). Well 299-W19-36 pumped at the least rate (31 L/min [8.2 gpm]) with a drawdown of 4.76 m (15.6 ft). Well 299-W19-43 average slightly higher than well 299-W19-36 (51 L/min [13.5 gpm]) with a smaller drawdown of 1.78 m (5.8 ft).

The maximum observed drawdown at adjacent monitoring wells was 0.32 m (1 ft) at well 299-W19-20, the closest well to 299-W19-39. This is a decrease in the drawdown calculated in FY02 (0.42 m [1.39 ft]). Drawdown of about 0.01 m (0.39 in.) was detected at well 299-W19-37 and 0.05 m (1.96 in.) at well 299-W19-35 was observed during the calculation period for well 299-W19-39, both which are significant decreases from FY02 (0.09 and 0.18 m [3.54 and 7.09 in.], respectively).

The drawdown calculations for wells 299-W19-36 and 299-W19-43 were made during periods in which well 299-W19-39 was operating at a relatively steady state of approximately 140 L/min (36.96 gpm). Drawdown at well 299-W19-43, the well closest to extraction well 299-W19-36 when pumping in early January 2003, was calculated at 0.03 m (1.2 in.), which is a decrease from FY02 of 50% (0.06 m [2.36 in.]). Drawdown at well 299-W19-37 was 0.01 m (0.39 in.) and is negligible at well 299-W19-35 when the drawdown at well 299-W19-39 is taken in to account.

When well 299-W19-43 was pumping water, drawdown at monitoring well 299-W19-36 during the June shutdown and restart of well 299-W19-43 was 0.02 m (0.787 in.). At well 299-W19-37, drawdown was 0.05 m (1.96 in.) and was negligible at well 299-W19-35, with respect to the drawdown caused by the pumping of well 299-W19-39. Given the differences in pumping rates, the results indicating the effects of well 299-W19-39 being more widely evident well than either 299-W19-36 or 299-W19-43 are not surprising. Furthermore, well 299-W19-43 has a greater impact than well 299-W19-36.

The drawdown also determines the radius of influence of the pumping well. The radius of influence represents the farthest extent that drawdown may be observed with steady-state pumping at an extraction well. The radius of influence can be used as a check on the modeled plume capture area. It should be noted that the radius of influence is about twice that of the capture zone. The drawdown observed laterally and downgradient from the extraction well may not be great enough to overcome the prevailing gradient in the aquifer. The radius of influence of the extraction wells was not calculated due to lack of well coverage.

Some additions to the water-level monitoring network are necessary to continue monitoring the effectiveness of the pump-and-treat operation. As previously mentioned, the declining water table has eliminated many wells from the current monitoring network (see Table C-1). As noted earlier, water-level declines at well 299-W19-20 rendered the well non-operational in March 2003, and it will be replaced with new well "K." Although able to take groundwater samples, well 299-W19-40 can no longer function as a water-level monitoring well. Well 299-W19-46 will add monitoring coverage to the south in FY04, but there will be no hydraulic data coverage downgradient and to the southeast of the plume until a replacement well is installed for 299-W19-40. With the reconfiguration of the extraction system and the conversion of well 299-W19-43 to an extraction well, there is no longer hydraulic coverage upgradient and of the northwest portion of the plume.

C2.0 200-ZP-1 OPERABLE UNIT AQUIFER RESPONSE

The following subsections discuss the response of the aquifer to the operation of 200-ZP-1 OU pump-and-treat operations during FY03. This response is discussed in terms of the hydraulic and contaminant changes observed and the numerical modeling results from data collected during FY03. These observations and analyses are based on data gathered from the existing network of wells in the 200-ZP-1 OU.

C2.1 HYDRAULIC MONITORING

The automated water-level monitoring network, installed in June 1996, measured groundwater elevation data from as many as 21 wells on an hourly basis during FY03. Water levels in the five extraction wells and five injection wells (Figures C-5 and C-6, respectively) are monitored and recorded by the 200-ZP-1 treatment system's operator interface computer. Figures C-7 through C-11 provide hydrographs of representative monitoring wells. Depth-to-water tape measurements provide references for determining water-level elevation. The elevation and contours of the groundwater table across the 200-ZP-1 OU are presented in Figure C-12. The water level across the baseline plume area has declined by 3.5 to 4 m (11.5 to 13.1 ft) since June 1996.

The unconfined aquifer at the 200-ZP-1 OU continues to decline. The decline rate is calculated based on the data from wells 299-W18-24 and 299-W18-01, which are assumed to be located outside the area of influence of the extraction and injection wells. Based on data collected from these wells (Figure C-11), the water-level rate of decline has slowed to 0.32 m/yr (1 ft/yr) in FY03, from 0.40 m/yr (1.31 ft/yr) in FY01, and 0.36 m/yr (1.18 ft/yr) in FY02. This rate of decline is less than that calculated at the 200-UP-1 OU (0.38 m/yr [1.25 ft/yr]).

As a comparison with long-term trends, well 699-39-79, located adjacent to injection well 299-W18-36, has been active since November 1948, and well 299-W15-1 has been active since December 1948 (Figure C-13). At well 699-39-79, water-level elevations have risen dramatically, from 129.3 m (424.2 ft) amsl in to 145.9 m (478.7 ft) in December 1958, an increase of 16.6 m (54.5 ft) under the influence of 216-U-10 Pond and other waste site discharges. The water table elevation peaked in December 1977 at 147.35 m (483.4 ft) amsl and has declined since October 1984, to 139.2 m (456.7 ft) by September 2003. At least another 9.9 m (32.5 ft) of decline is needed to approach pre-Hanford levels.

Similarly, well 299-W15-1, near the core of the current carbon tetrachloride plume, has exhibited a similar pattern of change over a similar range to that for well 699-39-79. Water-level monitoring was initially at 131.58 m (431.7 ft) amsl in December 1948. Following a steep increase to 146.25 m (479.8 ft) amsl in May 1956, the water-level trend varied slightly more than observed for well 699-39-79, before data collection was largely halted between 1965 and 1994. A steeper rate in water-level elevation declines has been observed during the last 10 years. Water levels dropped from 142.35 m (467 ft) amsl in September 1994 to 136.64 m (445 ft) in July 2003. At this point, at least a 5.1-m (16.7-ft) decrease may be expected around the baseline plume in the foreseeable future.

The overall decline is impacting the pump-and-treat operations through the loss of available head in the extraction wells. At least one well (299-W18-24) went dry in FY03 and another (299-W15-16) is expected to go dry within 2 years. Well 299-W15-30, located 15 m (49.2 ft) north of well 299-W15-16, is screened at similar elevations of the groundwater and will provide a suitable alternate for both water quality and water-level measurements. Well 299-W15-30 has been equipped with an automatic water-level recording system since July 1996 and has been within 1 to 2 cm (0.39 to 0.79 in.) of well 299-W15-16 elevations. Regular sampling and analysis of groundwater was restarted at well 299-W15-30 in FY04.

C2.2 DRAWDOWN

Drawdown analyses are performed to evaluate the extent of the impact of the pump-and-treat system and to determine whether the aquifer response to the pump-and-treat system has remained consistent or has changed during the year. This evaluation has been performed and reported in previous annual reports (DOE-RL 1998, 1999, 2000, 2001). The drawdown and buildup calculations for this report were performed using the same methodology described in these previous annual reports using the data collected during FY03. Table C-2 summarizes available data regarding drawdown and buildup in the extraction, injection, and monitoring wells for FY03 and compares it to FY02 data.

C2.2.1 Extraction and Injection Well Hydraulic Responses

In general, drawdown and specific capacity calculated in the extraction wells has remained relatively consistent, except when changes in pumping rates resulted in changes in the drawdown. The pumping rates have been declining from FY98 through FY03. This decline in pumping rates can be attributed to the combination of the declining water table, which causes loss of available head in the extraction wells, and the loss of well efficiency that can be expected in a constantly pumped well.

During FY03, drawdowns ranged from 1.04 m (3.41 ft) to 10.07 m (33.04 ft) and decreased in all of the wells compared to the preceding year. Using drawdown and pumping information, the specific capacities were calculated for the extraction wells. The FY03 and FY02 specific capacities are listed for comparison in Table C-2.

During FY03, buildup (or mounding) at the injection wells ranged from 12.8 m (41.99 ft) to 26.5 m (86.9 ft). This is an overall decrease compared to the preceding fiscal year. All injection wells were used during FY03, but the northern three (299-W15-29, 299-W18-36, and 299-W18-37) were routinely used. Using injecting rates and buildup information, the specific capacities have been calculated for the injection wells. The FY03 and FY02 specific capacities are listed for comparison in Table C-2.

C2.2.2 Monitoring Well Hydraulic Responses

Drawdown and buildup at the observation wells are used to evaluate the effectiveness of pumping and injecting in the aquifer, away from the extraction and injection wells. Table C-2 summarizes the results of FY03 analysis and compares these results to drawdown and buildup measured for FY02.

The drawdown and buildup at all of the monitoring wells has declined compared to FY02. The drawdown and buildup results in conjunction with the declining water table indicate that the hydraulic flow field is still being modified in the area of the pump-and-treat system by the local and regional declines in the water table. The uniform decrease in drawdown at the monitoring wells indicates that the radius of influence, in general, is also decreasing. The hydraulic gradient and groundwater flow continue to move from the injection well field, toward the extraction wells, and the extraction well network continues to contain the high-concentration area of the plume, which continues to support remedial action objective performance criteria. The complete extent of the radius of influence of the extraction wells projects beyond the current monitoring well network cannot accurately be determined to the north or east of the pump-and-treat area. The overall impact to the aquifer downgradient of the extraction wells, particularly around the TX and U Tank Farms, and to the east of the pump-and-treat system is unclear, and additional boreholes are needed to determine the impact.

C3.0 REFERENCES

DOE-RL, 1998, *Fiscal Year 1997 Annual Report for the 100-NR-2, 200-UP-1, and 200-ZP-1 Pump-and-Treat Operations and Operable Units*, DOE/RL-98-38, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1999, *Fiscal Year 1998 Annual Summary Report for the 200-UP-1, 200-ZP-1, and 100-NR-2 Pump-and-Treat Operations and Operable Units*, DOE/RL-99-02, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2000, *Fiscal Year 1999 Annual Summary Report for the 200-UP-1, 200-ZP-1, and 100-NR-2 Pump-and-Treat Operations and Operable Units*, DOE/RL-99-79, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2001, *Fiscal Year 2000 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*, DOE/RL-2000-71, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2002, *Sampling and Analysis Plan for the 200-UP-1 Groundwater Monitoring Well Network*, DOE/RL-2002-10, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Figure C-1. 200-UP-1 Water Table Map: Baseline Water Table, June 1995 Versus September 2003 Water Table.

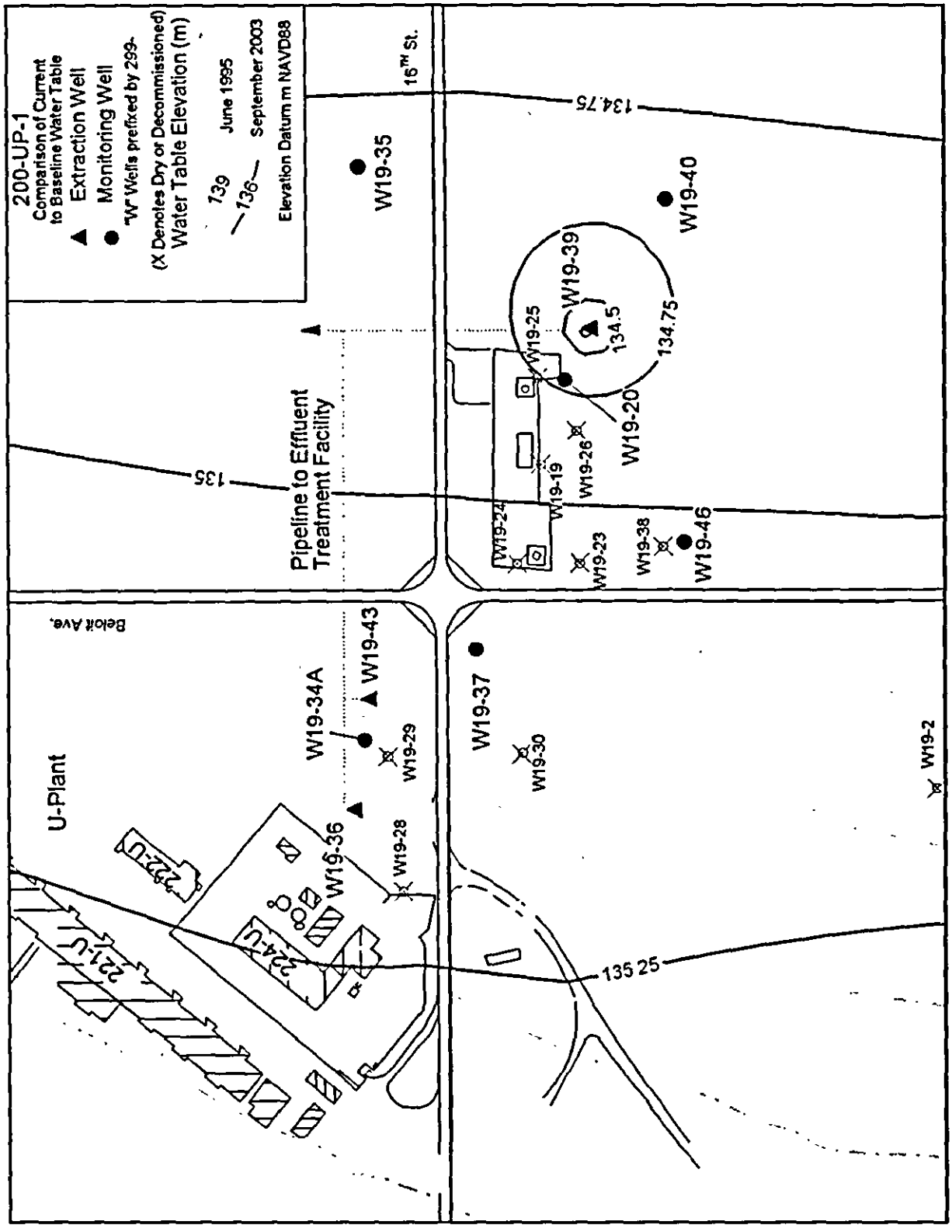
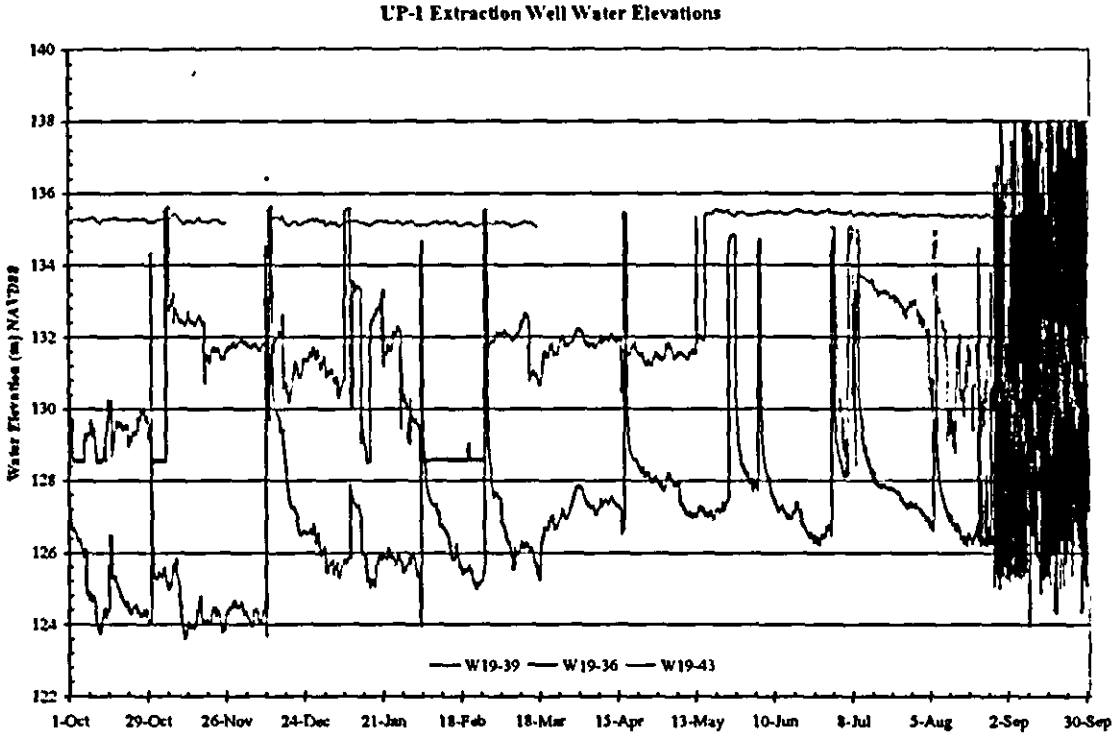


Figure C-2. Hydrographs of Extraction Wells 299-W19-39, 299-W19-36, and 299-W19-43, Plus Monitoring Wells 299-W19-20 and 299-W19-34A.



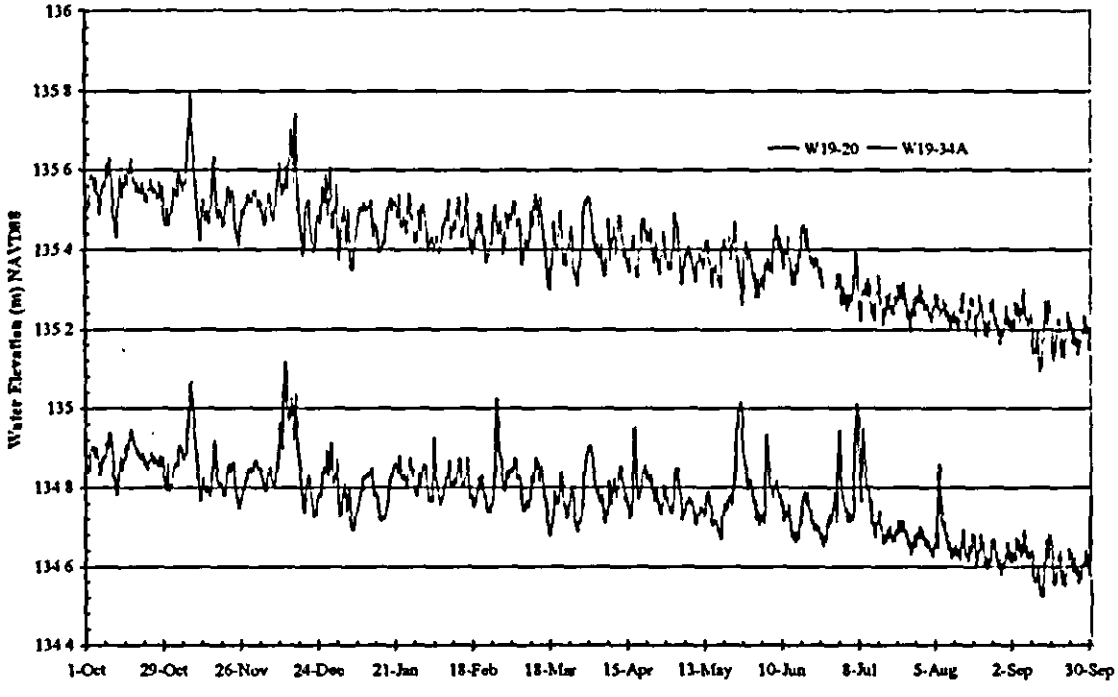


Figure C-3. Hydrographs of Monitoring Wells 299-W19-35 and 299-W19-37, Plus Calculation of Groundwater Level Decline Rate.

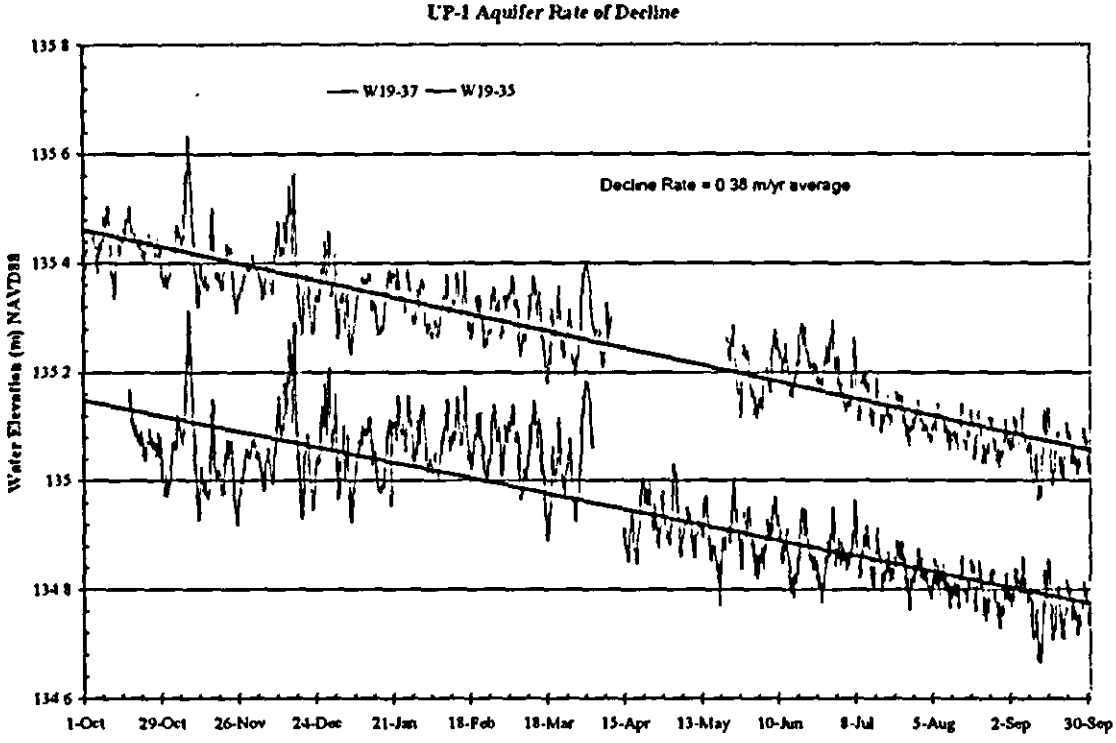


Figure C-4. 200-UP-1 Operable Unit Long-Term Water Levels.

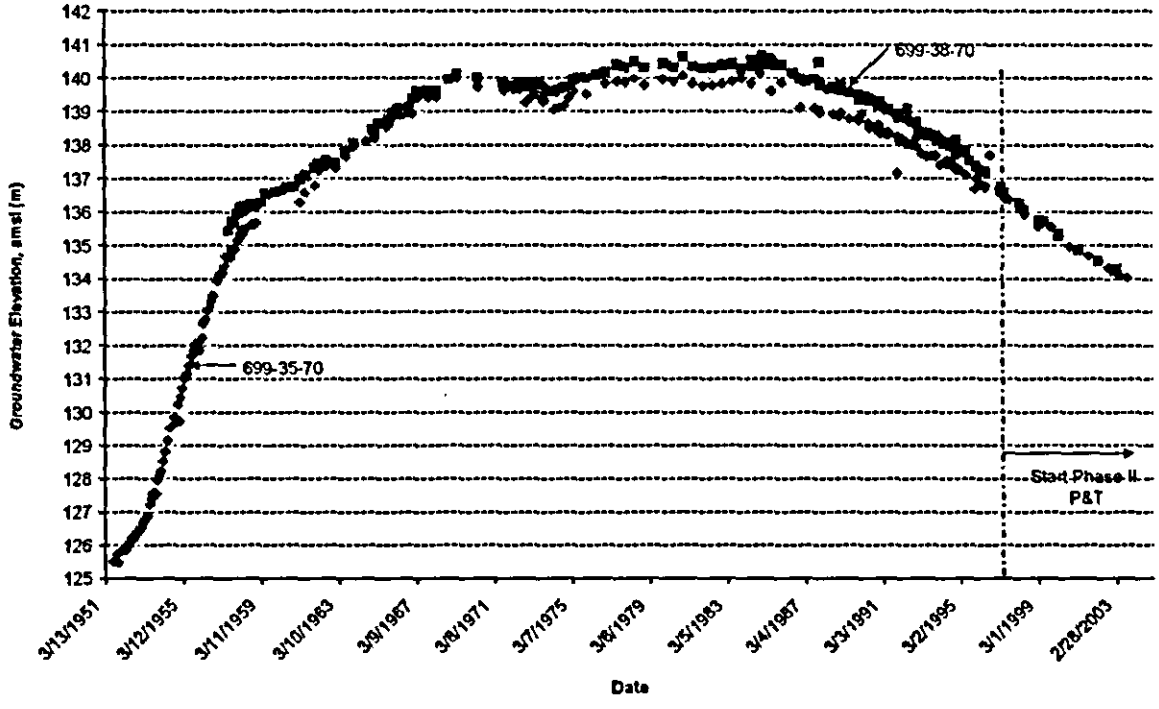


Figure C-5. Hydrographs of Extraction Wells 299-W15-33 and 299-W15-34, 299-W15-35 and 299-W15-32, and 299-W15-36. (3 sheets)

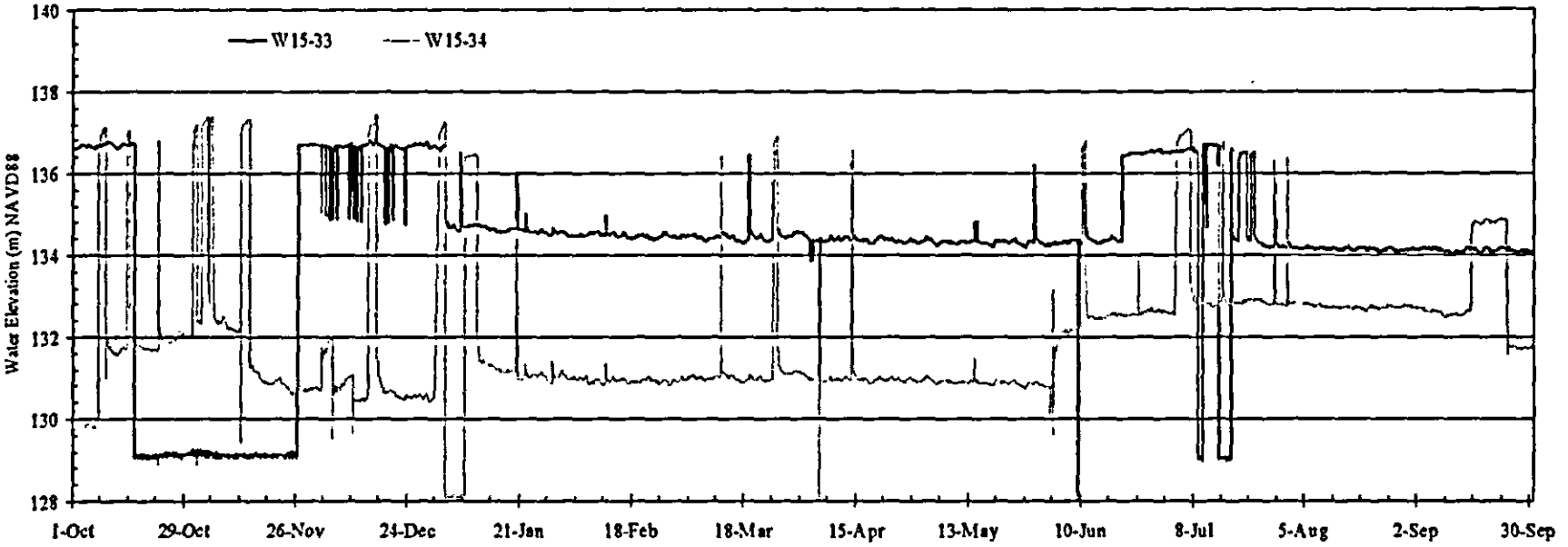


Figure C-5. Hydrographs of Extraction Wells 299-W15-33 and 299-W15-34, 299-W15-35 and 299-W15-32, and 299-W15-36. (3 sheets)

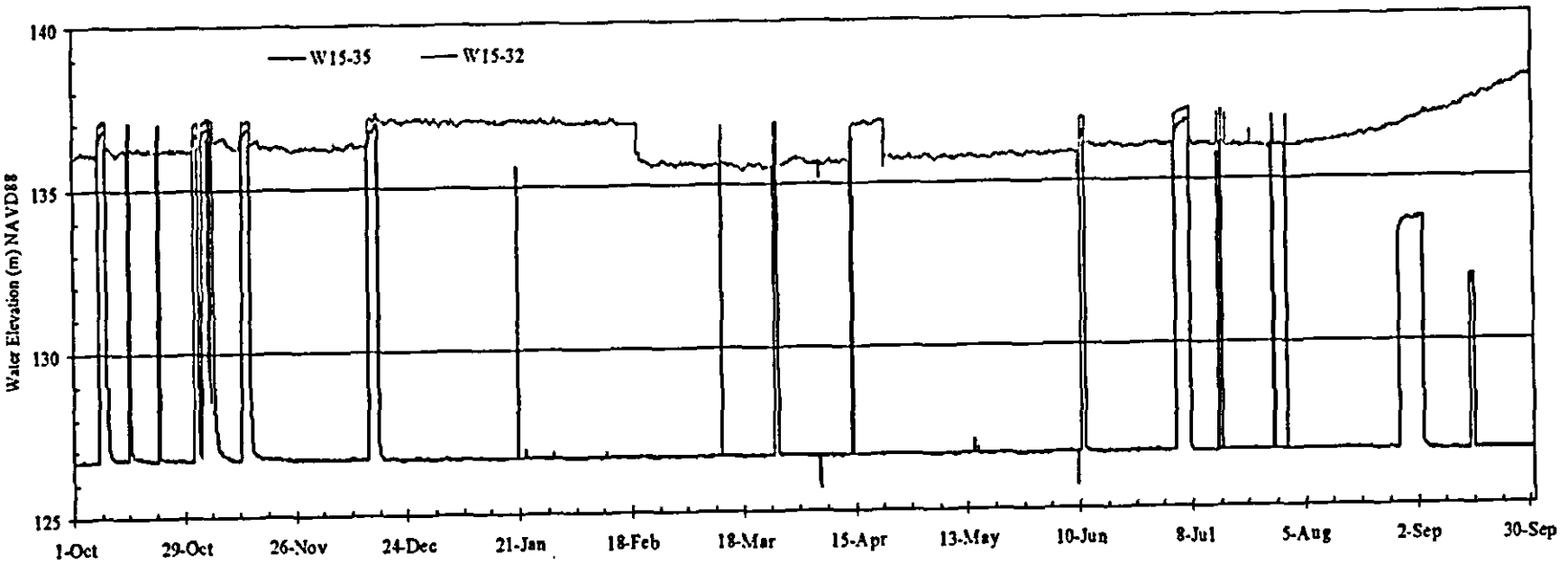


Figure C-5. Hydrographs of Extraction Wells 299-W15-33 and 299-W15-34, 299-W15-35 and 299-W15-32, and 299-W15-36. (3 sheets)

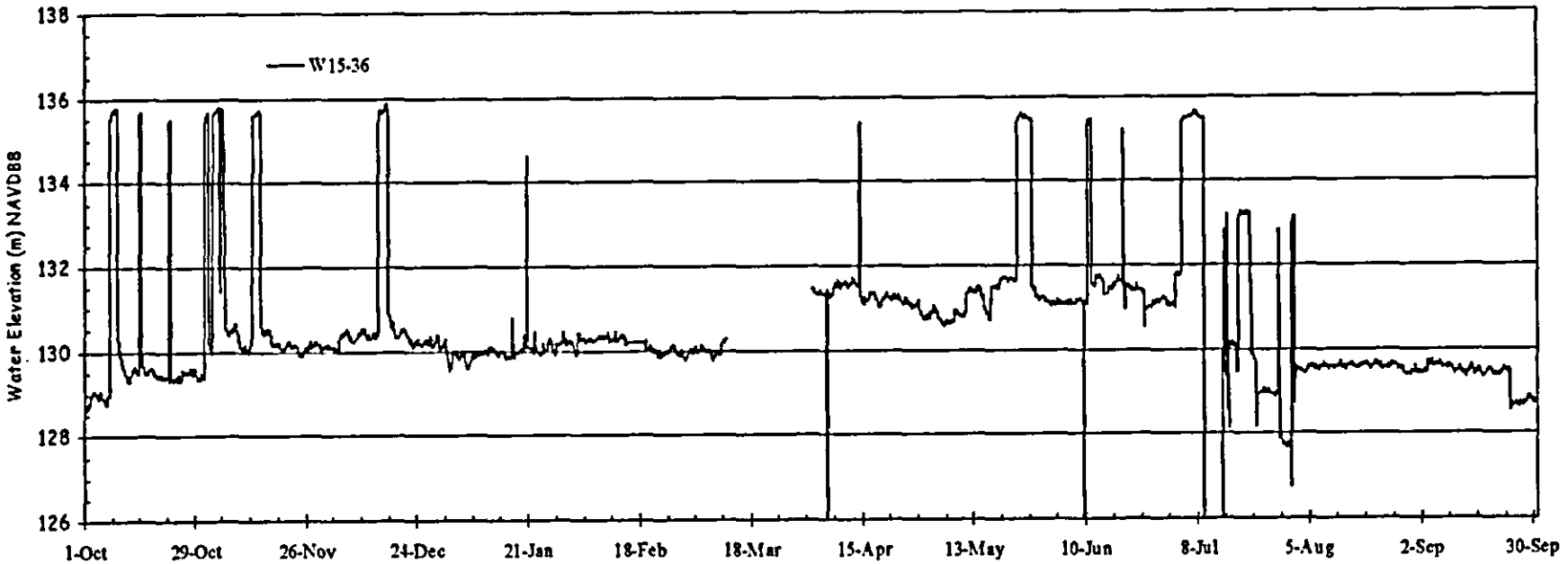


Figure C-6. Hydrographs of Injection Wells 299-W15-29 and 299-W18-36, 299-W18-37 and 299-W18-38, and 299-W18-38 and 299-W18-39. (3 sheets)

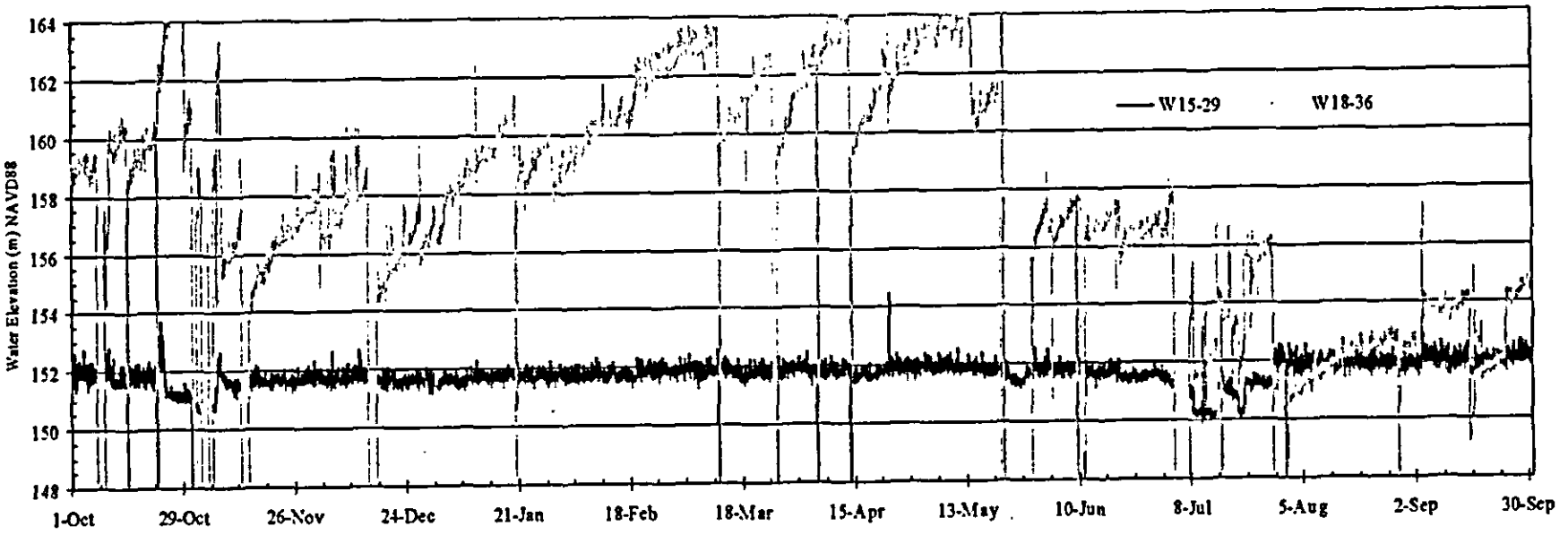


Figure C-6. Hydrographs of Injection Wells 299-W15-29 and 299-W18-36, 299-W18-37 and 299-W18-38, and 299-W18-38 and 299-W18-39. (3 sheets)

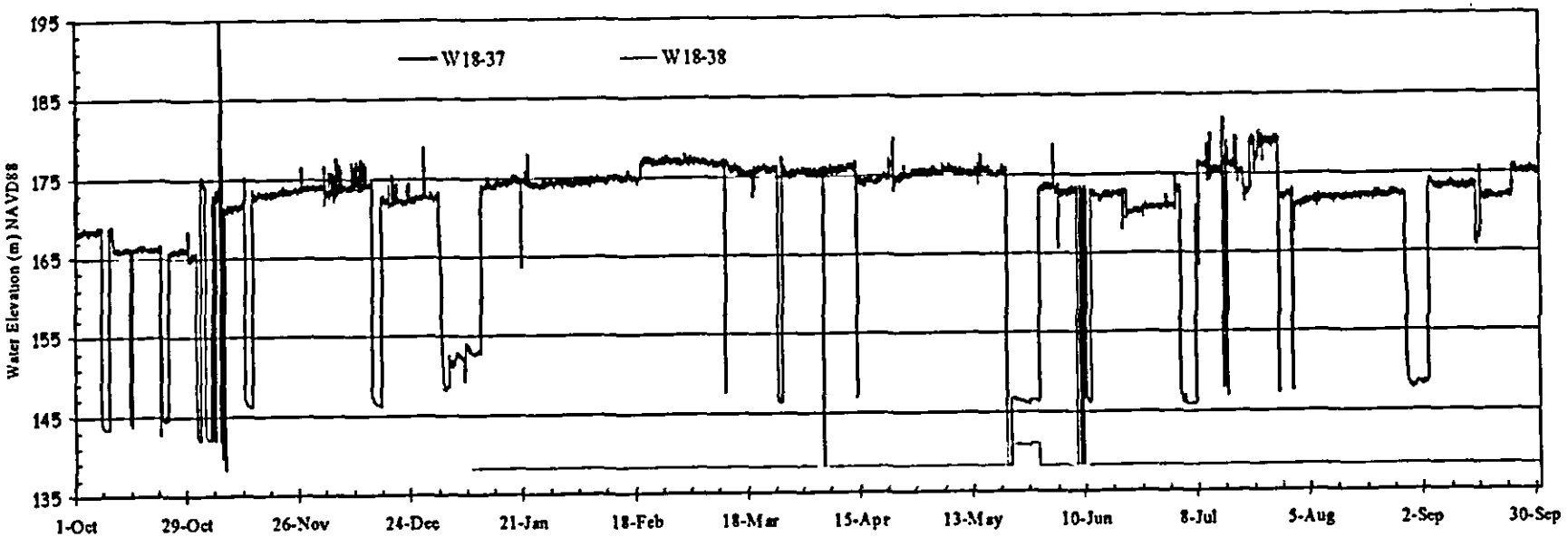
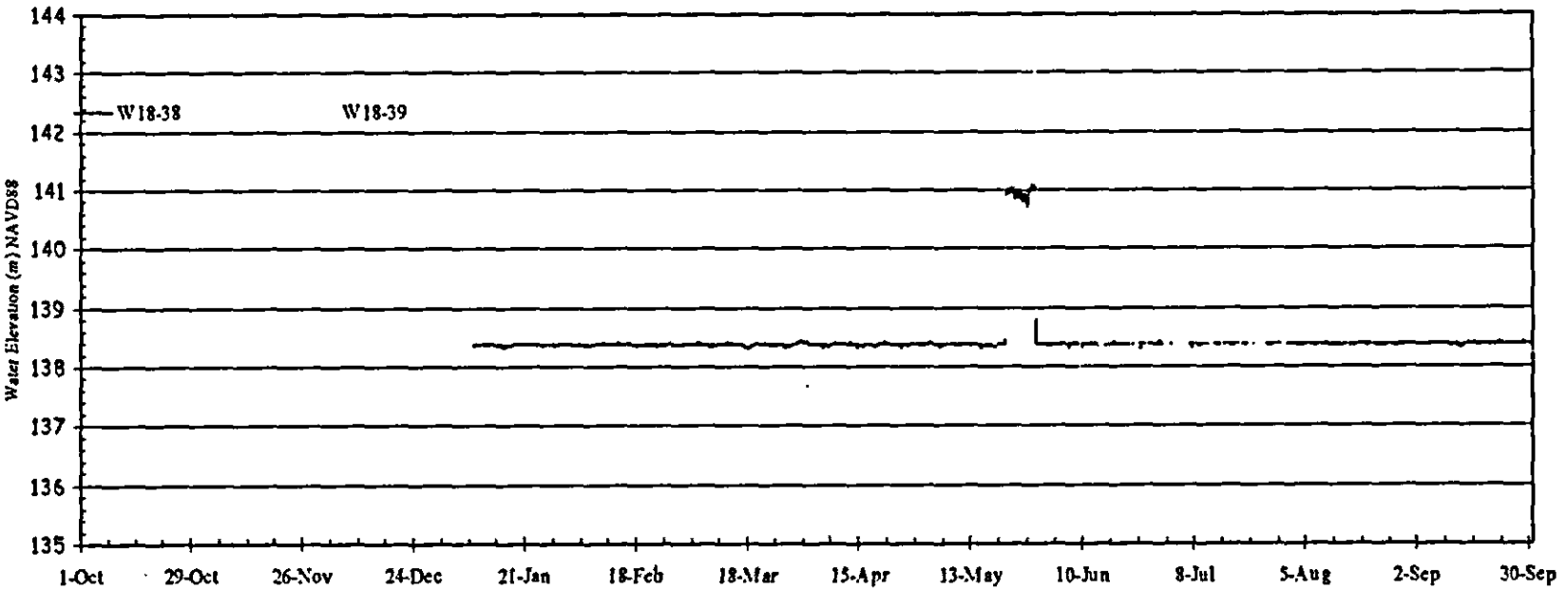


Figure C-6. Hydrographs of Injection Wells 299-W15-29 and 299-W18-36, 299-W18-37 and 299-W18-38, and 299-W18-38 and 299-W18-39. (3 sheets)



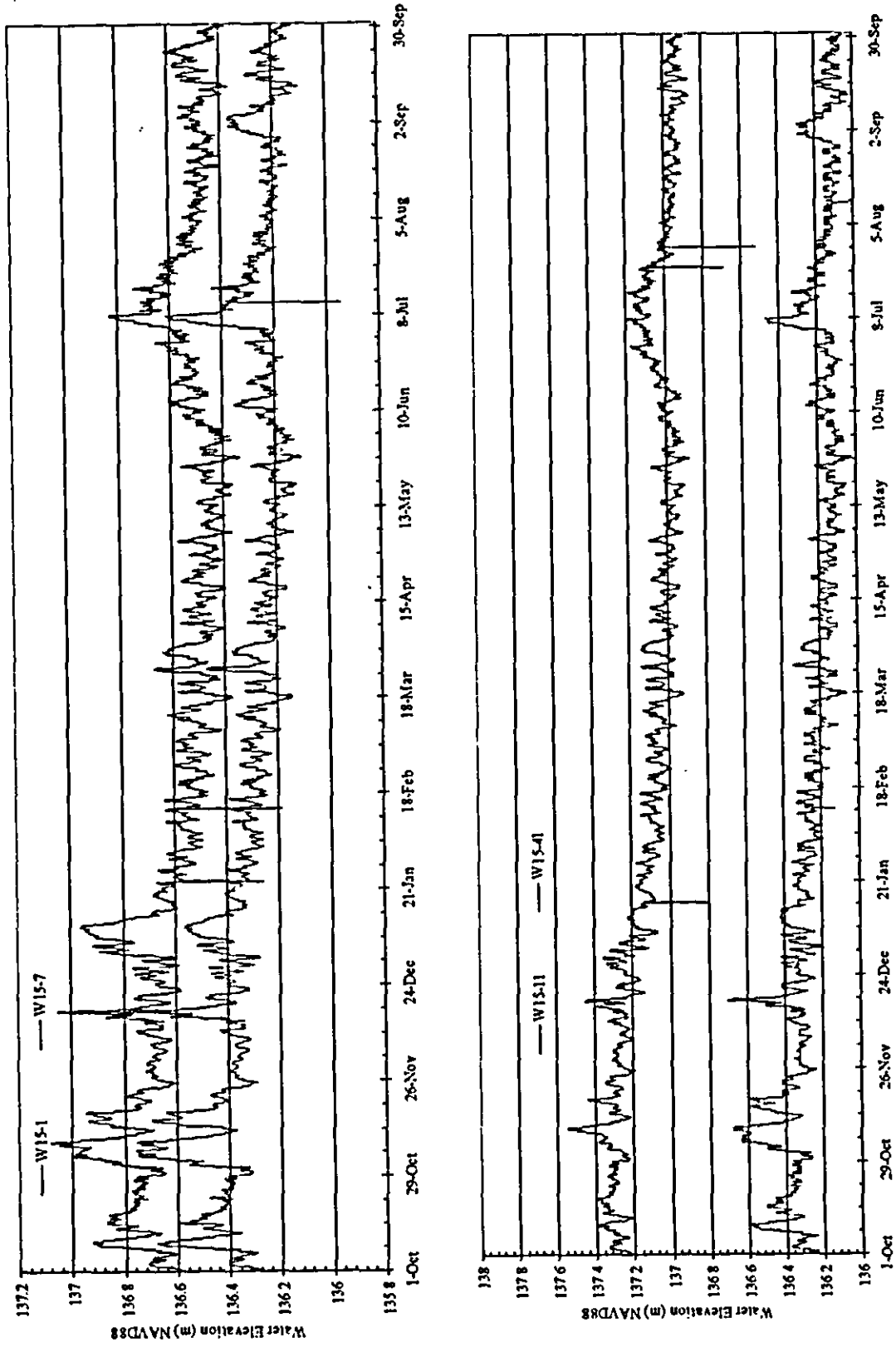
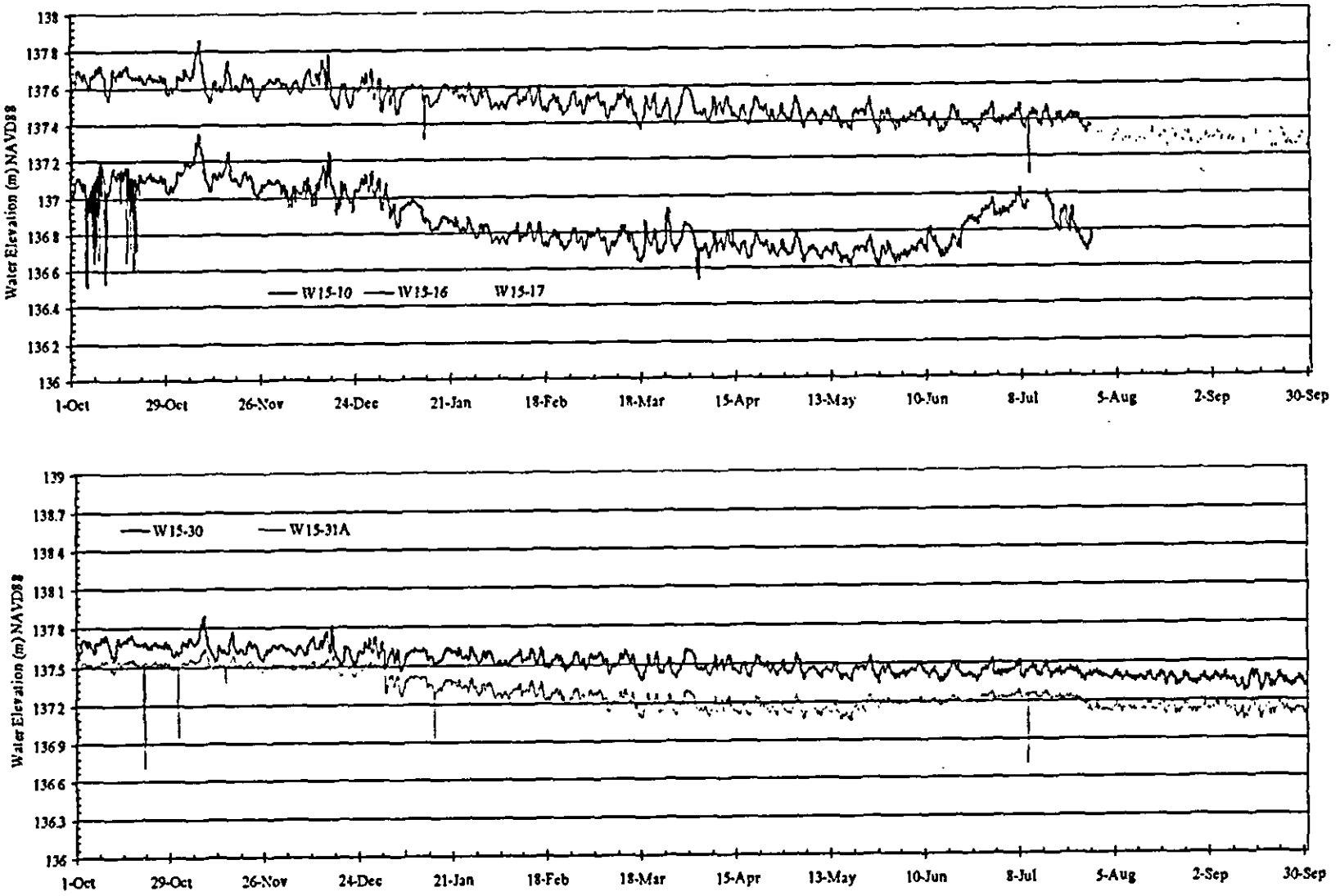


Figure C-7. Hydrographs of Monitoring Wells 299-W15-1, 299-W15-7, 299-W15-11, and 299-W15-41.

Figure C-8. Hydrographs of Monitoring Wells 299-W15-10, 299-W15-16, 299-W15-17, 299-W15-30, and 299-W15-31A.



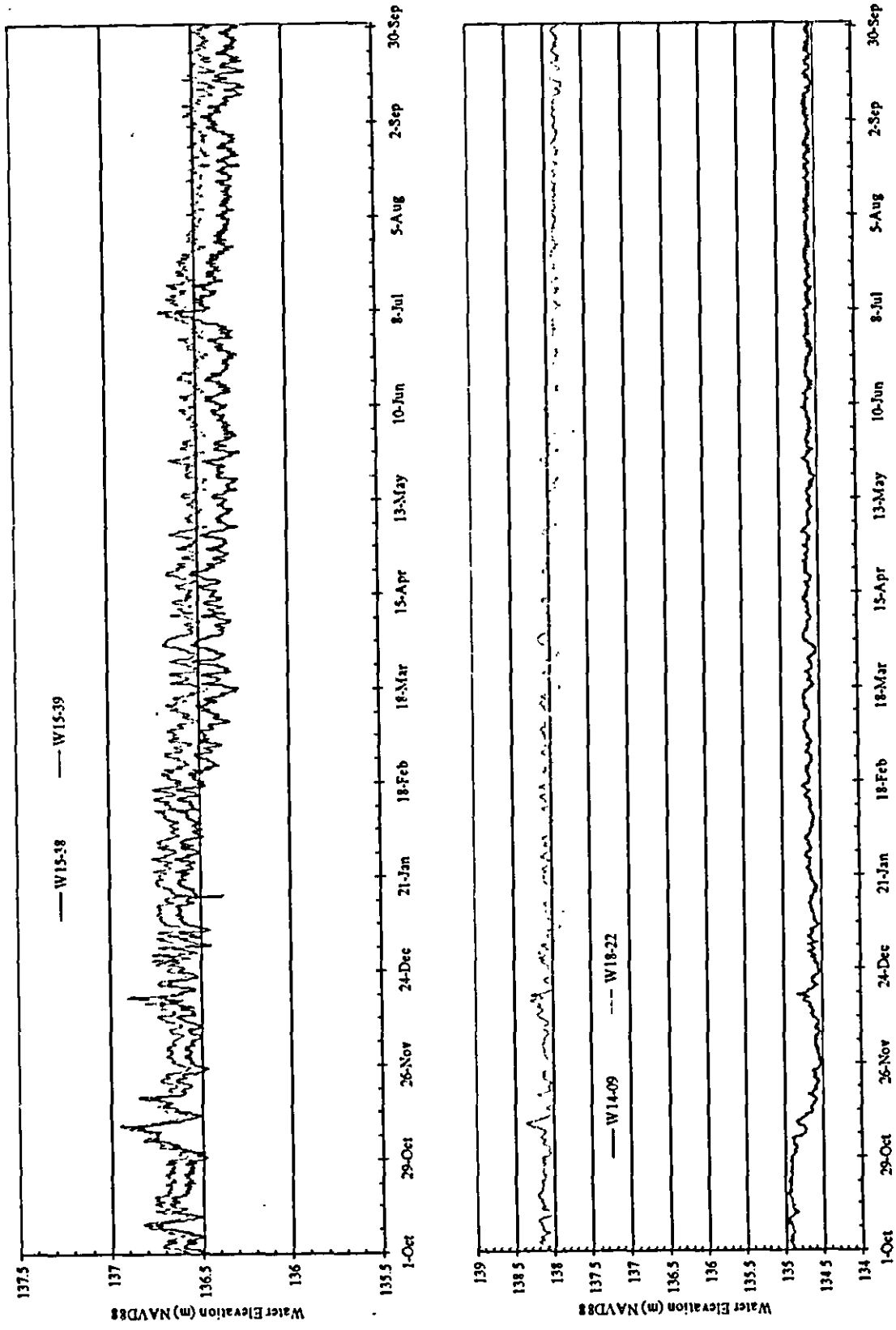


Figure C-9. Hydrographs of Monitoring Wells 299-W15-38, 299-W15-39, 299-W14-09, and 299-W8-22.

Figure C-10. Hydrographs of Monitoring Wells 699-39-79, 299-W18-23, 299-W18-21, and 299-W18-30.

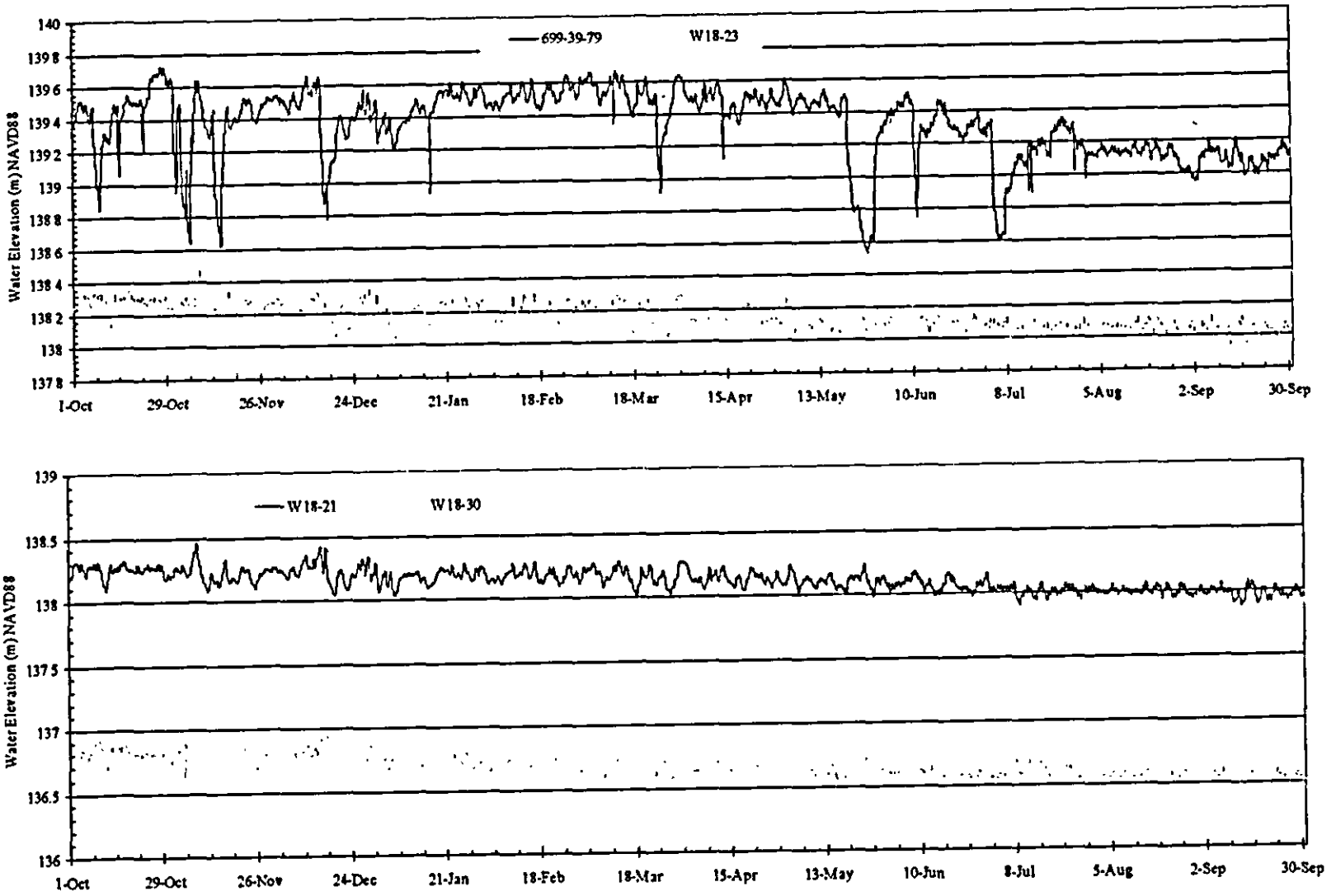


Figure C-11. Hydrographs of Monitoring Wells 299-W18-24 and 299-W18-01, Plus Calculation for Regional Groundwater Decline.

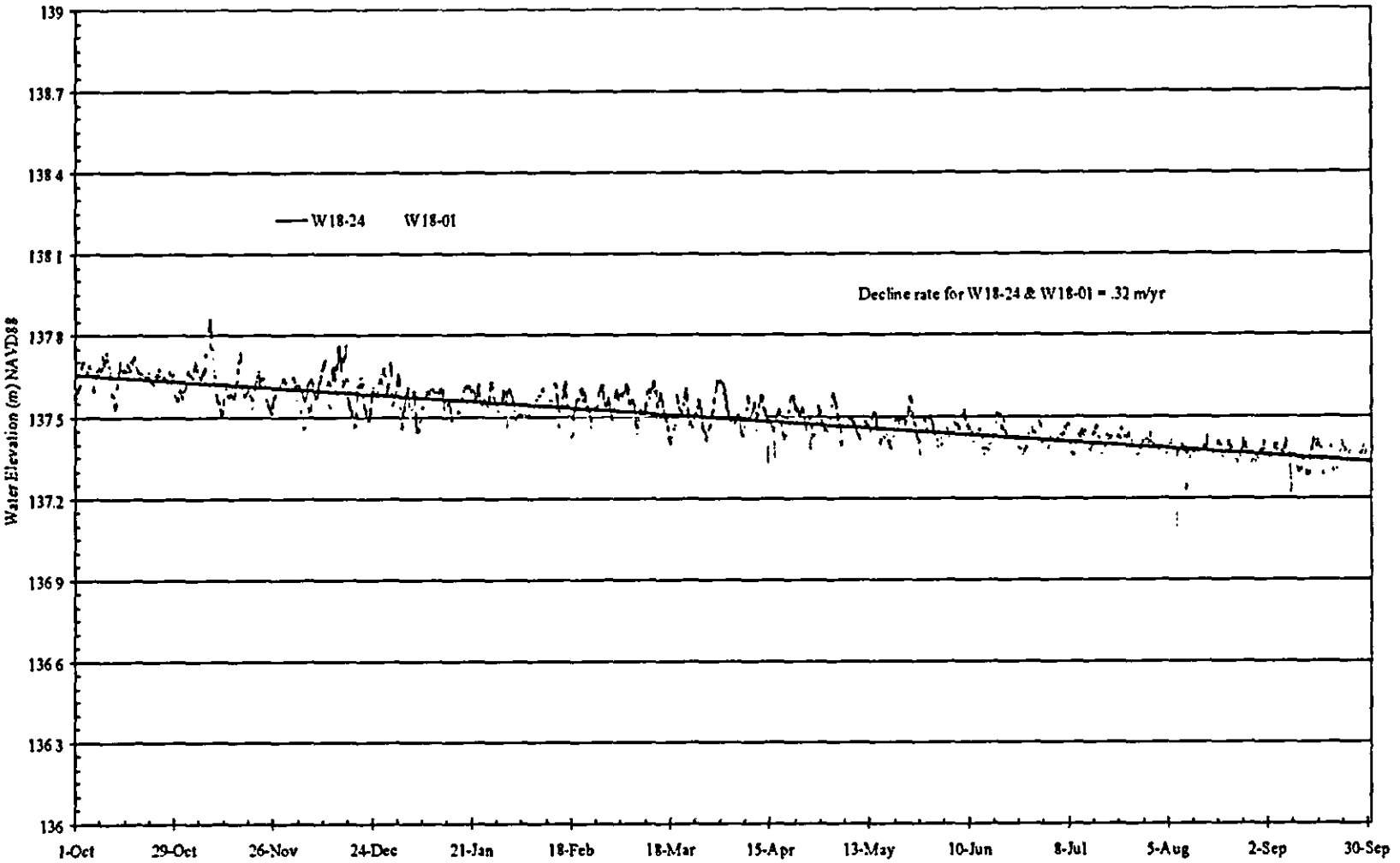


Figure C-12. 200-ZP-1 Water Table Map: Baseline June 1996 Water Table Versus September 2003 Water Table.

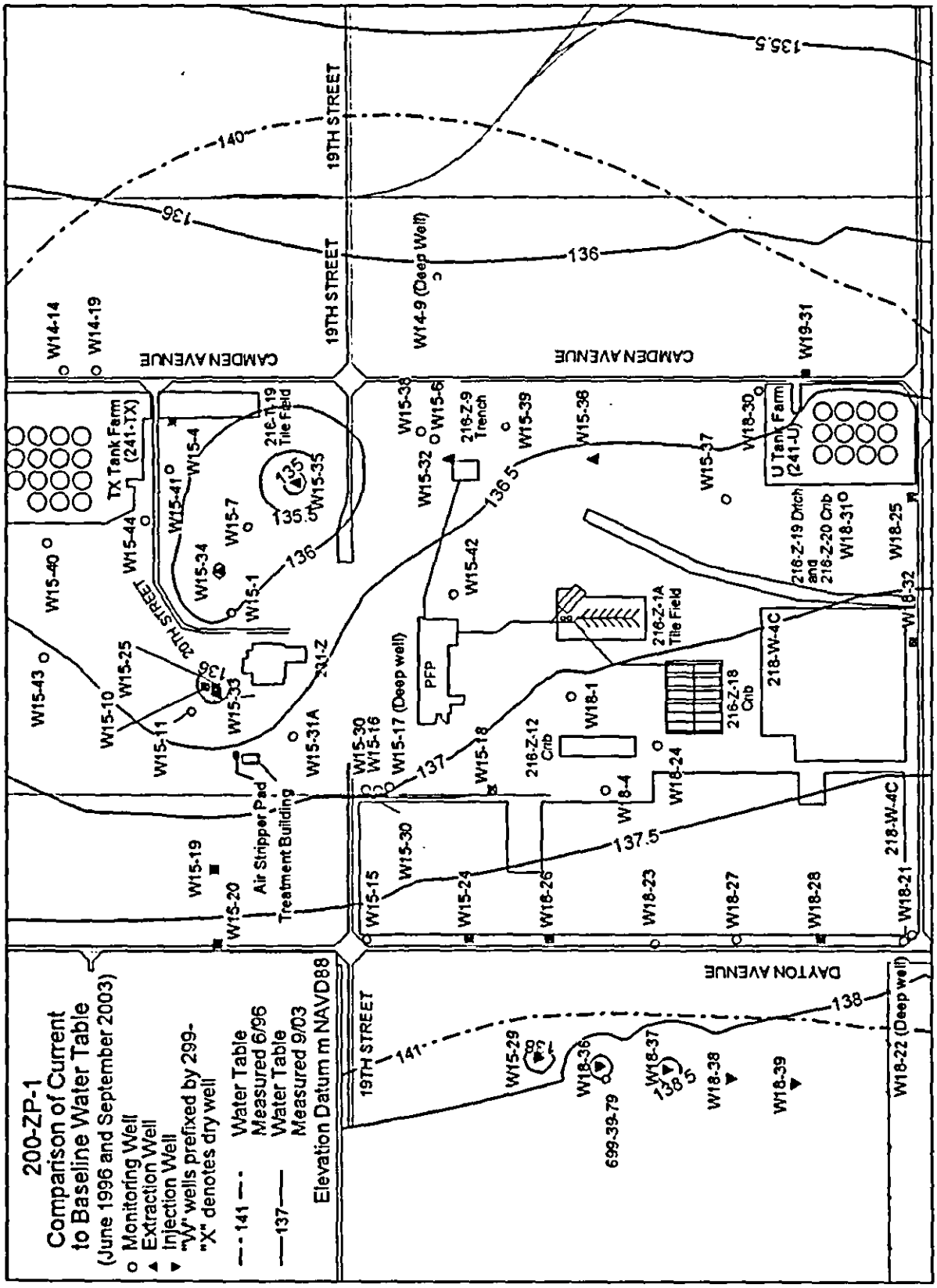


Figure C-13. 200-ZP-1 Operable Unit Long-Term Water Levels.

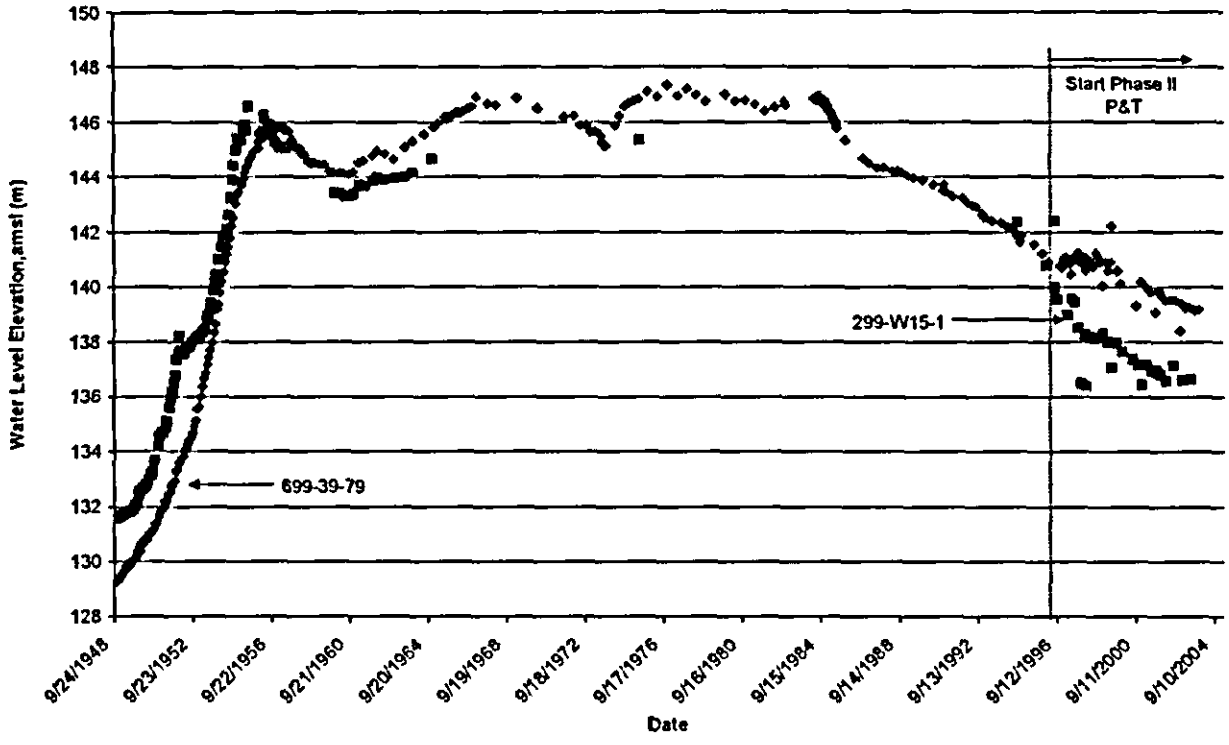


Table C-1. Effects of Declining Water Table on the 200-UP-1 Operable Unit Water-Level Monitoring Network.

Well Name	Direction from Extraction Pump	Well Type	Actual or Forecasted Date Dry
299-W19-19	Northwest	Near-field, upgradient	May 1999
299-W19-20[a]	Northwest	Near-field, upgradient	March 2003
299-W19-23	West/southwest	Mid-field, upgradient	July 2000
299-W19-24	West	Mid-field, upgradient	June 2000
299-W19-25	Northwest	Near-field, upgradient	February 1998
299-W19-26	West	Near-field, upgradient	August 2000
299-W19-28[b]	Northwest/southwest	Near-field, downgradient	November 1999
299-W19-29[b]	Northwest/southeast	Near-field, downgradient	December 2000
299-W19-30	West	Mid-field, upgradient	March 2001
299-W19-34A	West (39)/east (36)	Deep near-field	Beyond 2010
299-W19-35	Northeast	Boundary well, northeast downgradient	Beyond 2010
299-W19-36	Northwest	Extraction well	Beyond 2010
299-W19-37	Northwest	Mid-field, upgradient	FY09
299-W19-38	South/southwest	Southern boundary well	June 2001
299-W19-39	Center	Extraction well	Beyond 2010
299-W19-40[d]	Southeast	Downgradient	FY03
299-W19-43[c]	Northwest/southeast[c]	Extraction well	Beyond 2010
299-W19-46	South-southwest	Southern boundary well	Beyond 2010

NOTE: Shading indicates dry monitoring wells in FY03.

[a] Dry at times when extraction 299-W19-39 pumping, without pumping will go dry by April 2004.

[b] Originally monitored the former injection well.

[c] Started in FY03 as a monitoring well; converted to an extraction well mid-FY03.

[d] Well sampling expected for approximately +4 more years

FY = fiscal year

Table C-2. Summary of Drawdown and Buildup Measured at 200-ZP-1 Pump-and-Treat and Water-Level Monitoring Wells.

Well Name	*FY02/FY03*	FY02	FY03	FY02	FY03
	Buildup (-) or Drawdown (+) (m)	Flow Rate (L/min)		Specific Capacity (L/min/m)	
299-W15-32	*1.33*/1.04	34	34	25.9	32.7
299-W15-33	*7.52*/2.22	26	44	3.5	19.8
299-W15-34	*6.59*/4.54	74	73	11.2	16.1
299-W15-35	*10.51*/10.07	293	272	27.9	27.1
299-W15-36	*6.99*/4.18	92	77	13.2	18.4
299-W15-01	*0.62*/0.25	–	–	–	–
299-W15-7	*0.65*/0.31	–	–	–	–
299-W15-10	*0.68*/0.24	–	–	–	–
299-W15-11	*0.39*/0.14	–	–	–	–
299-W15-16	*0.05*/0.03	–	–	–	–
299-W15-25	*0.48*/0.33	–	–	–	–
299-W15-30	*0.07*/0.03	–	–	–	–
299-W15-31A	*0.12*/0.01	–	–	–	–
299-W15-38	*0.37*/0.17	–	–	–	–
299-W15-39	*0.23*/0.09	–	–	–	–
299-W15-41	*0.54*/0.25	–	–	–	–
299-W18-30	*0.10*/0.04	–	–	–	–
299-W15-29	*-13.70*/12.8	271	151	19.8	11.8
299-W18-36	*-20.37*/17.4	205	194	10.1	11.1
299-W18-37	*ND*/26.5	130	120	–	4.5
299-W18-38	*-0.18*/ND[a]	–	–	–	–
299-W18-39	*ND*/ND[a]	–	–	–	–
299-W18-21	*-0.16*/0.03	–	–	–	–
299-W18-23	*-0.19*/0.05	–	–	–	–
699-39-79	*-1.18*/0.66	–	–	–	–

[a] The transducers in 299-W18-38 and 299-W18-39 do not have the accuracy to make any meaningful calculation.
ND = No data for that year.

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APPENDIX D

TREND PLOTS FOR WELLS AT THE 200-UP-1 OPERABLE UNIT

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CONTENTS

FIGURES

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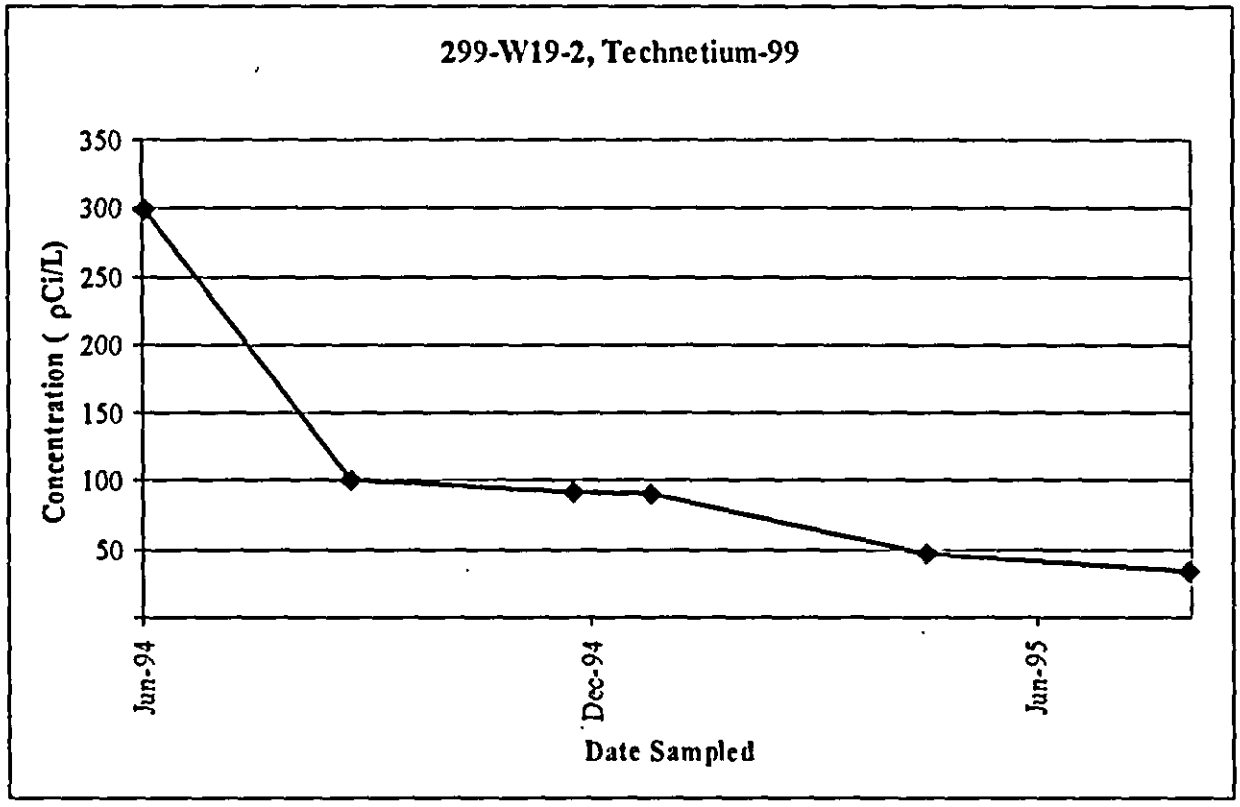
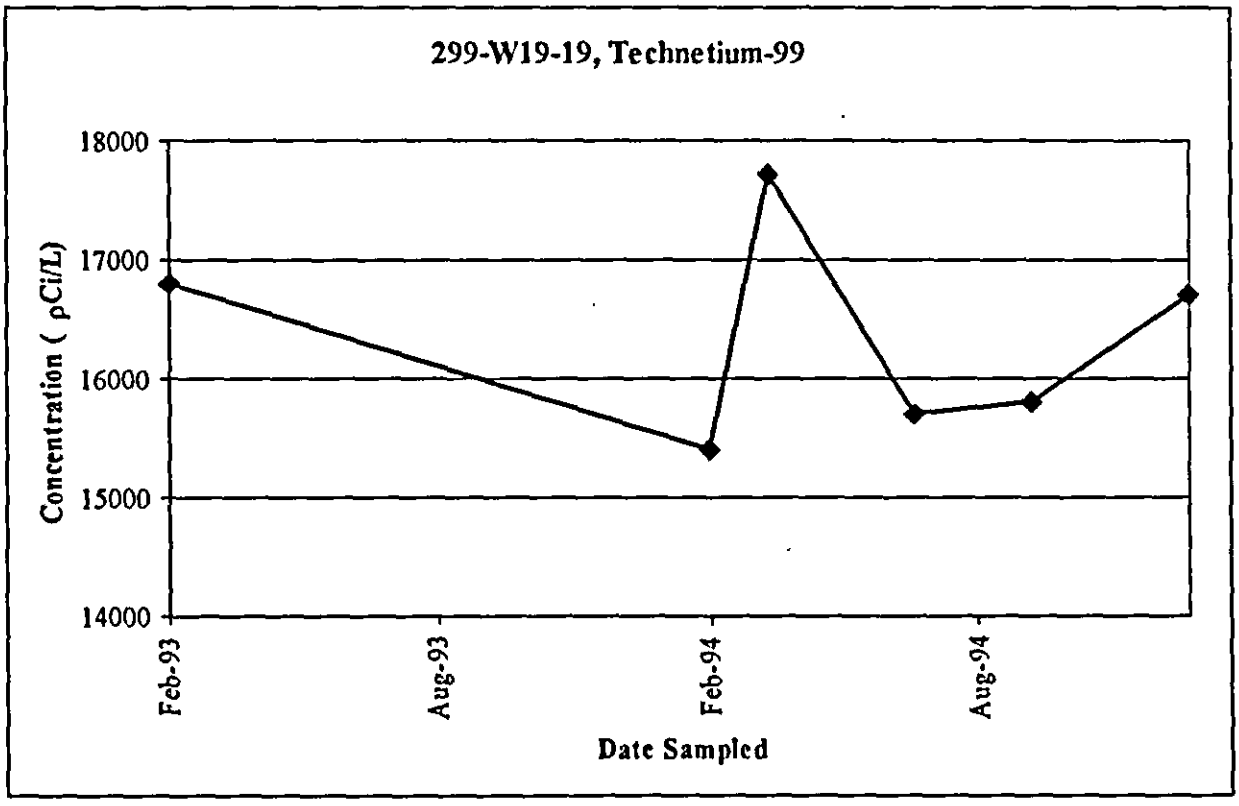
Figure D-1. 200-UP-1 Groundwater Operable Unit, Technetium-99 Concentration Trends at Selected Monitoring Wells. (11 sheets)





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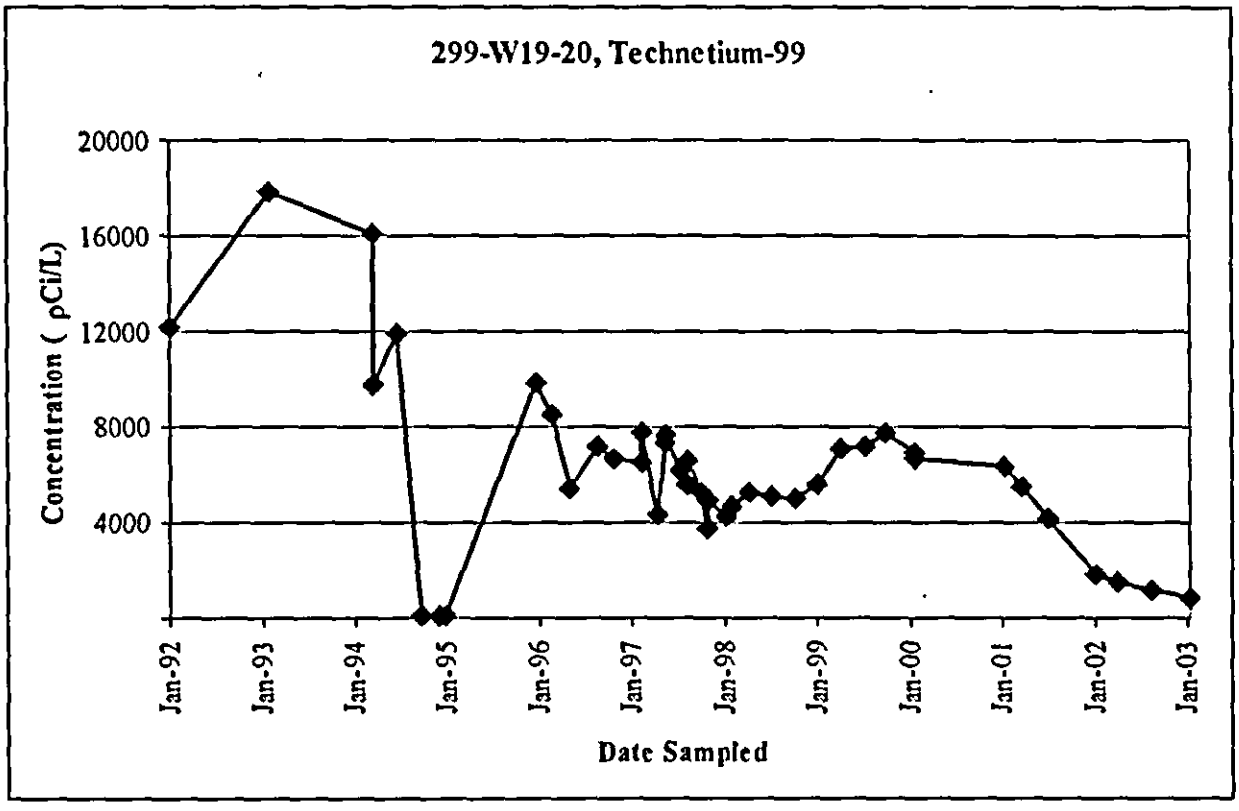

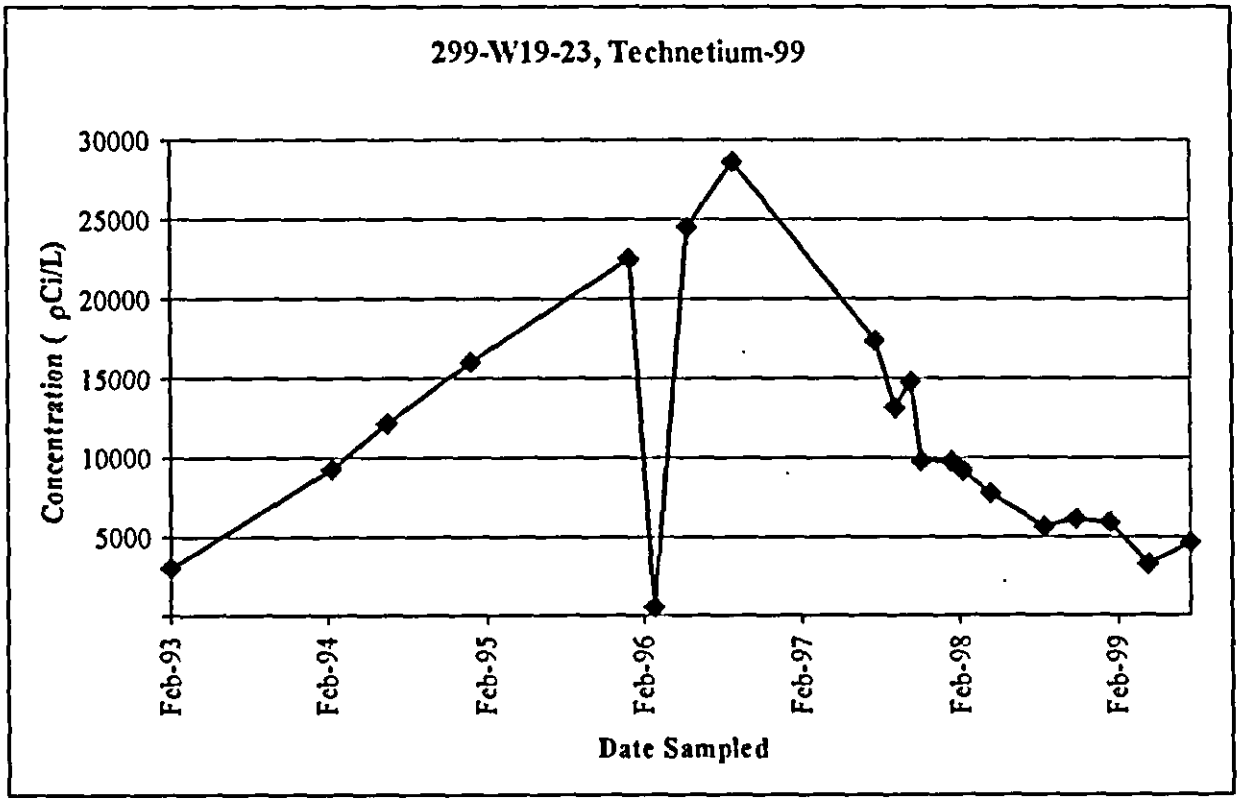

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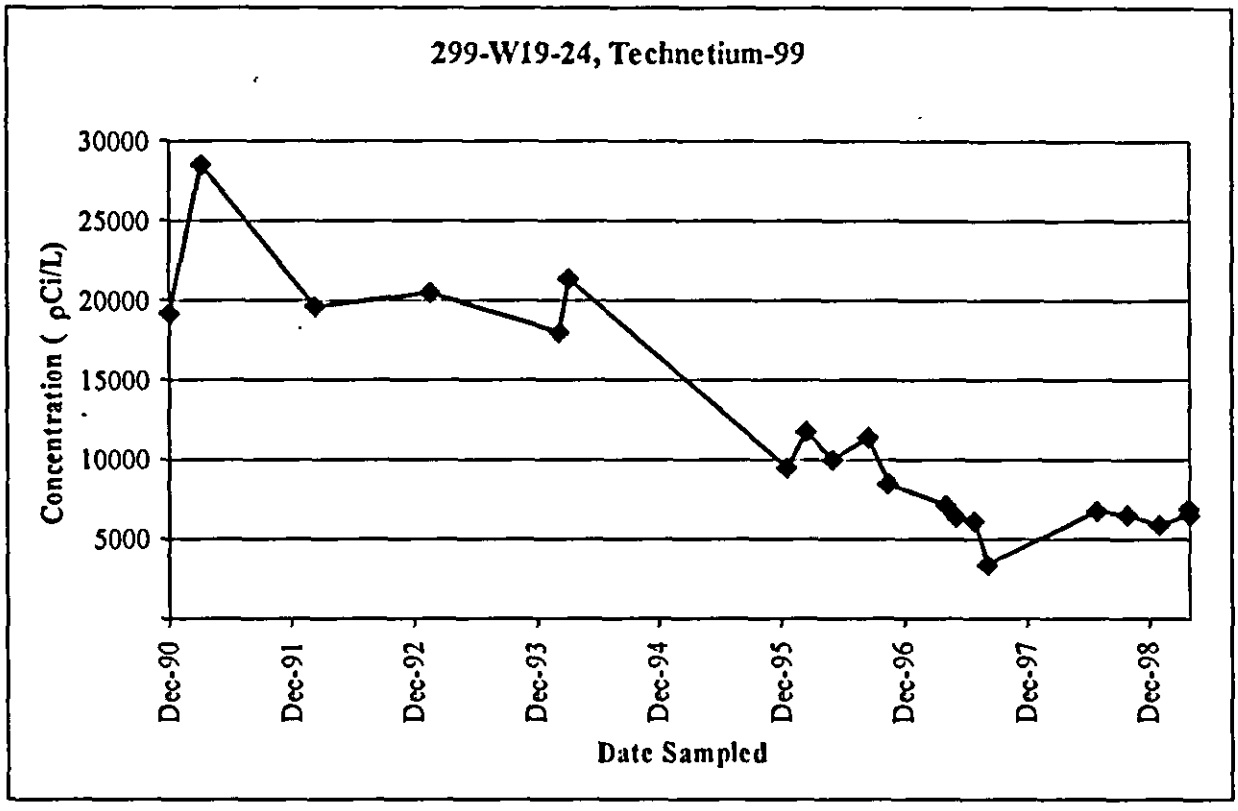

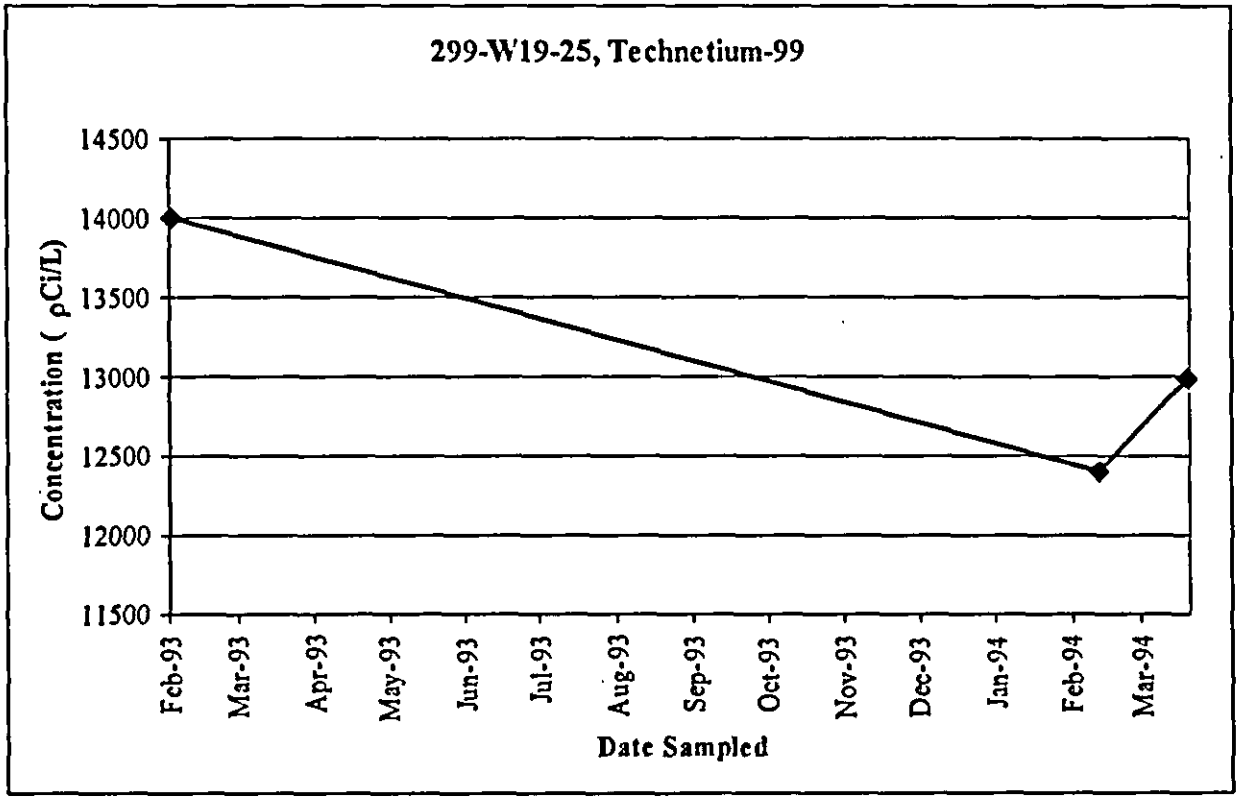

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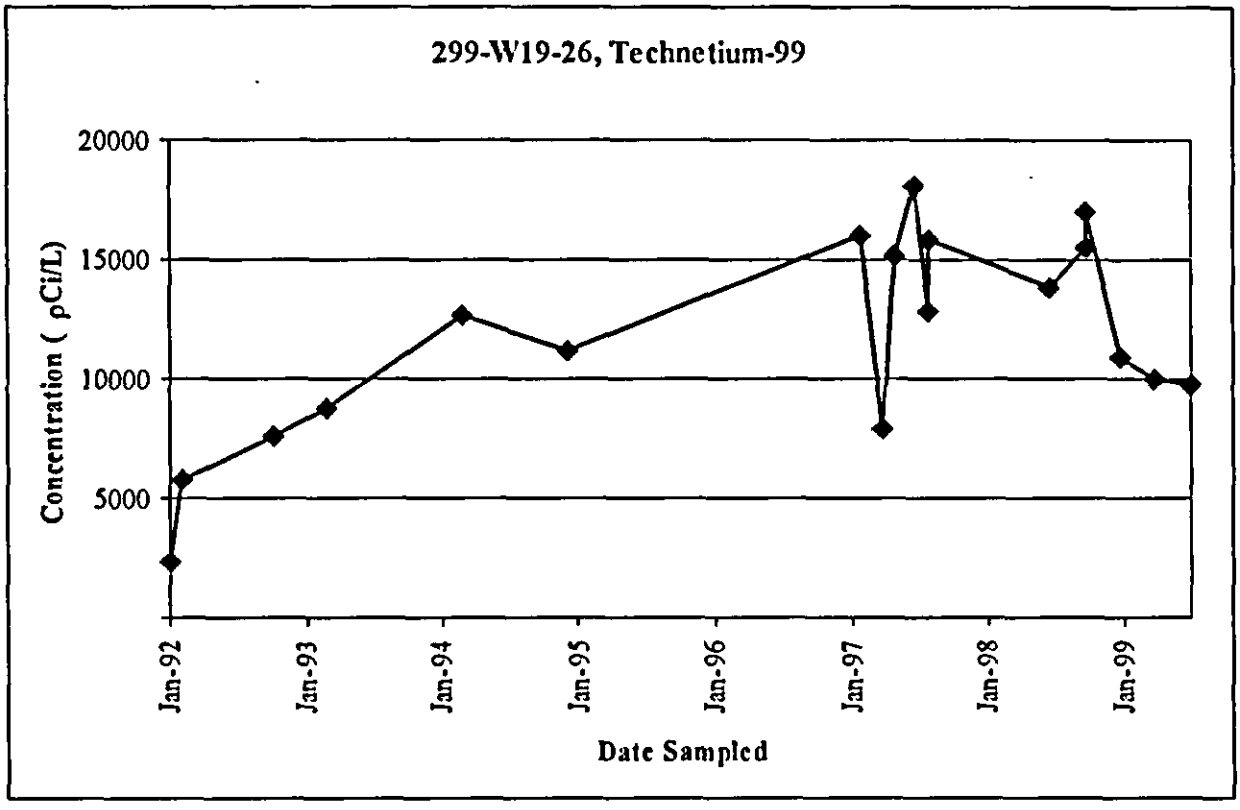

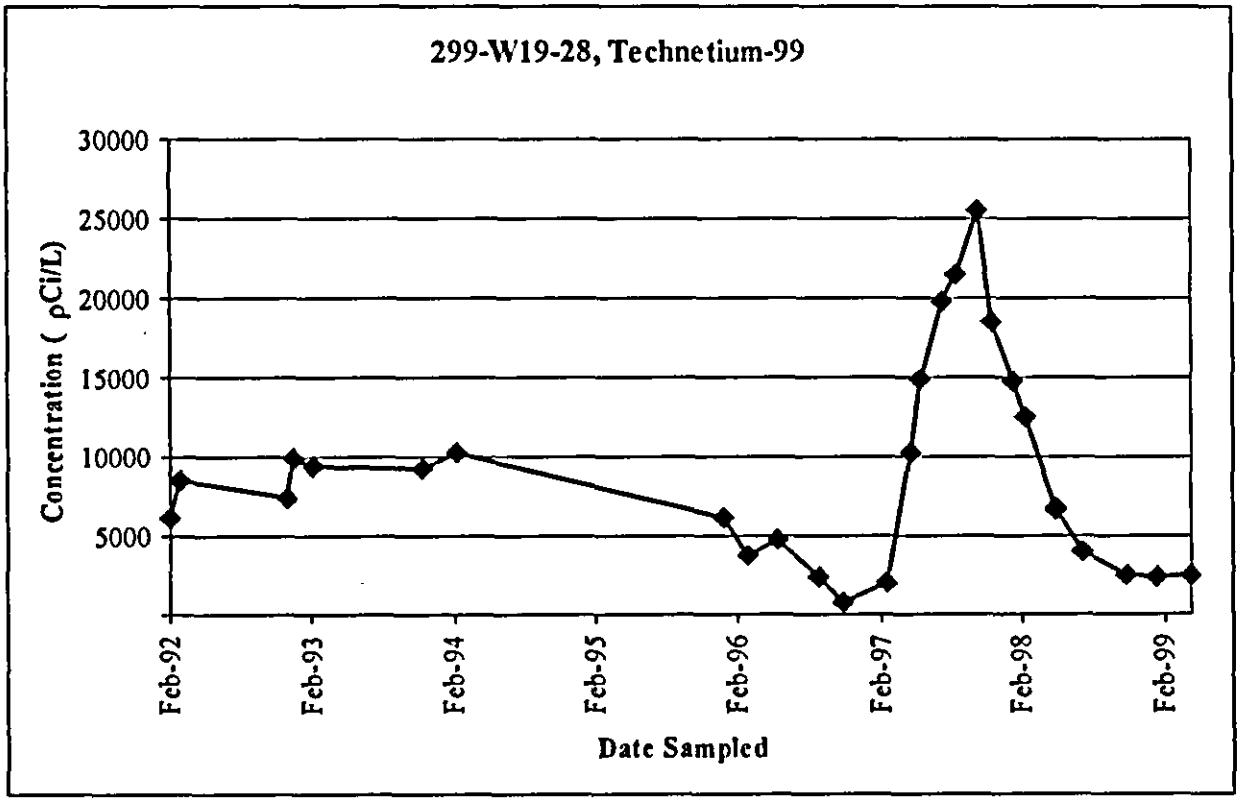

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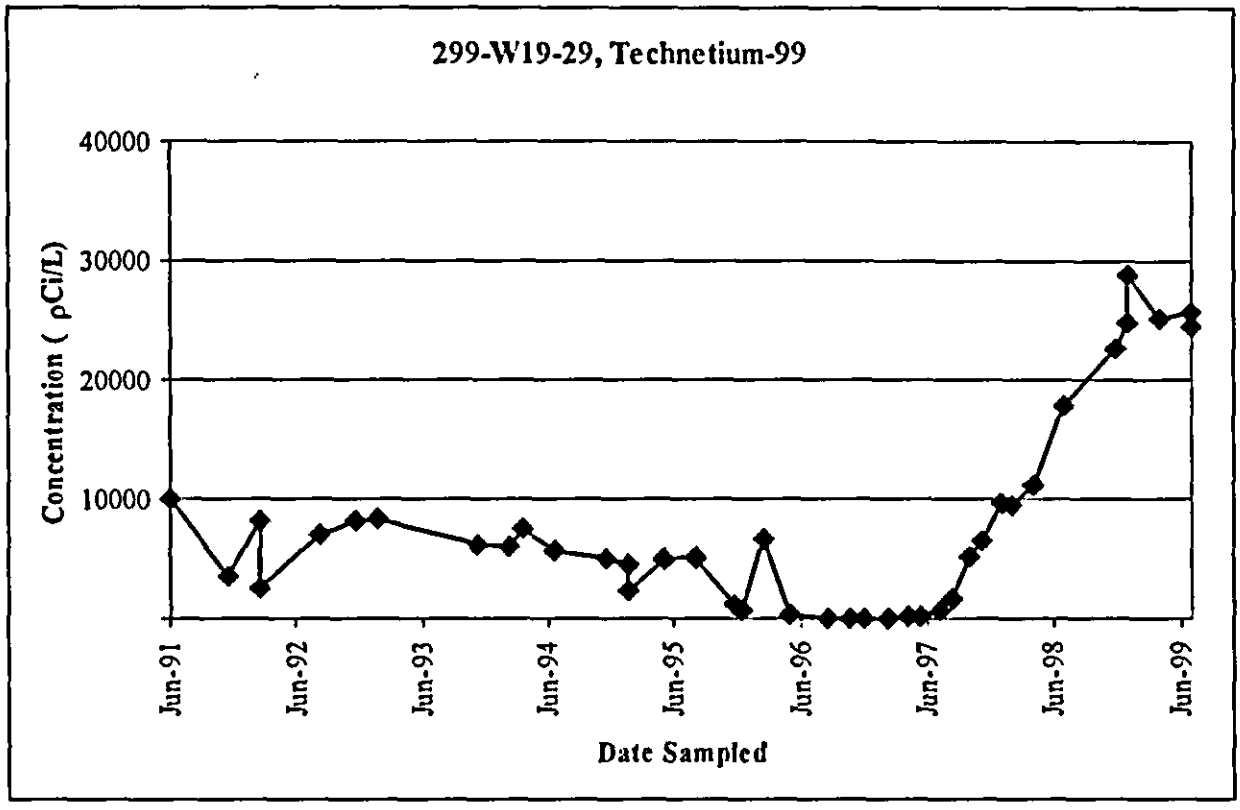

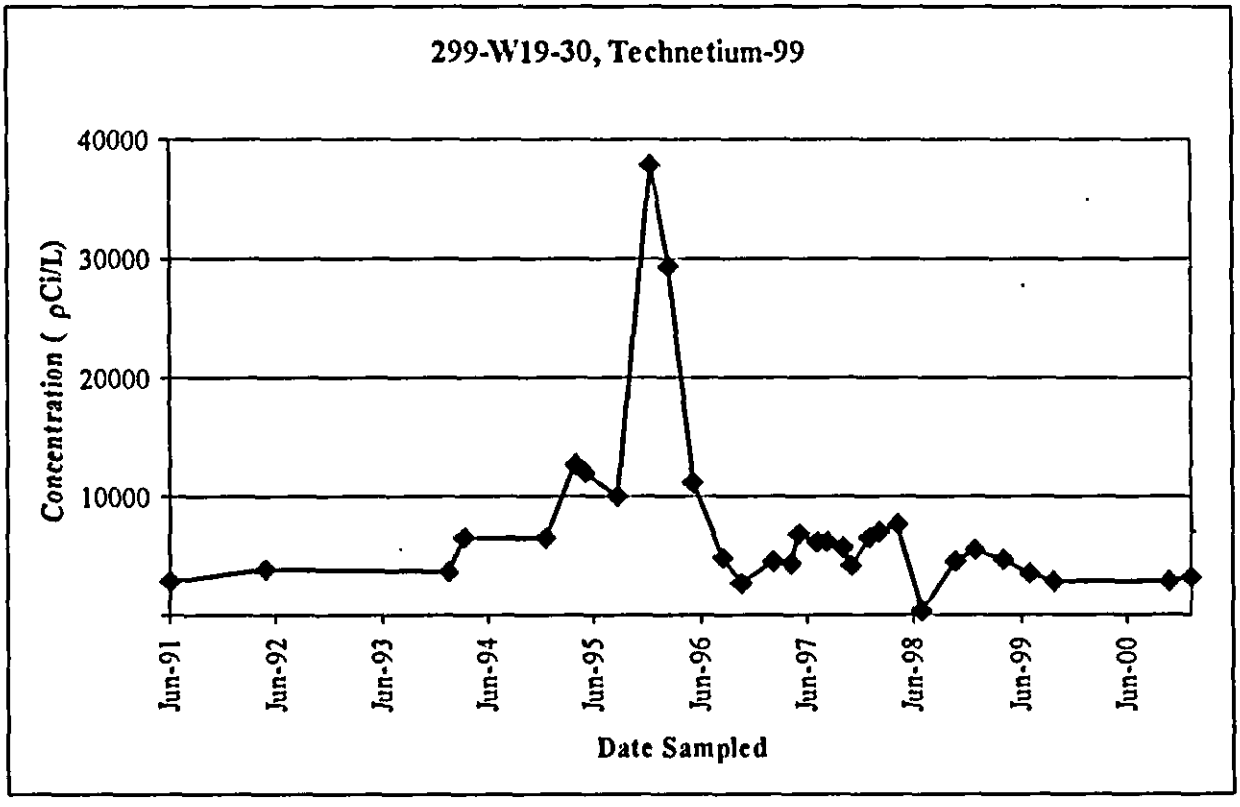

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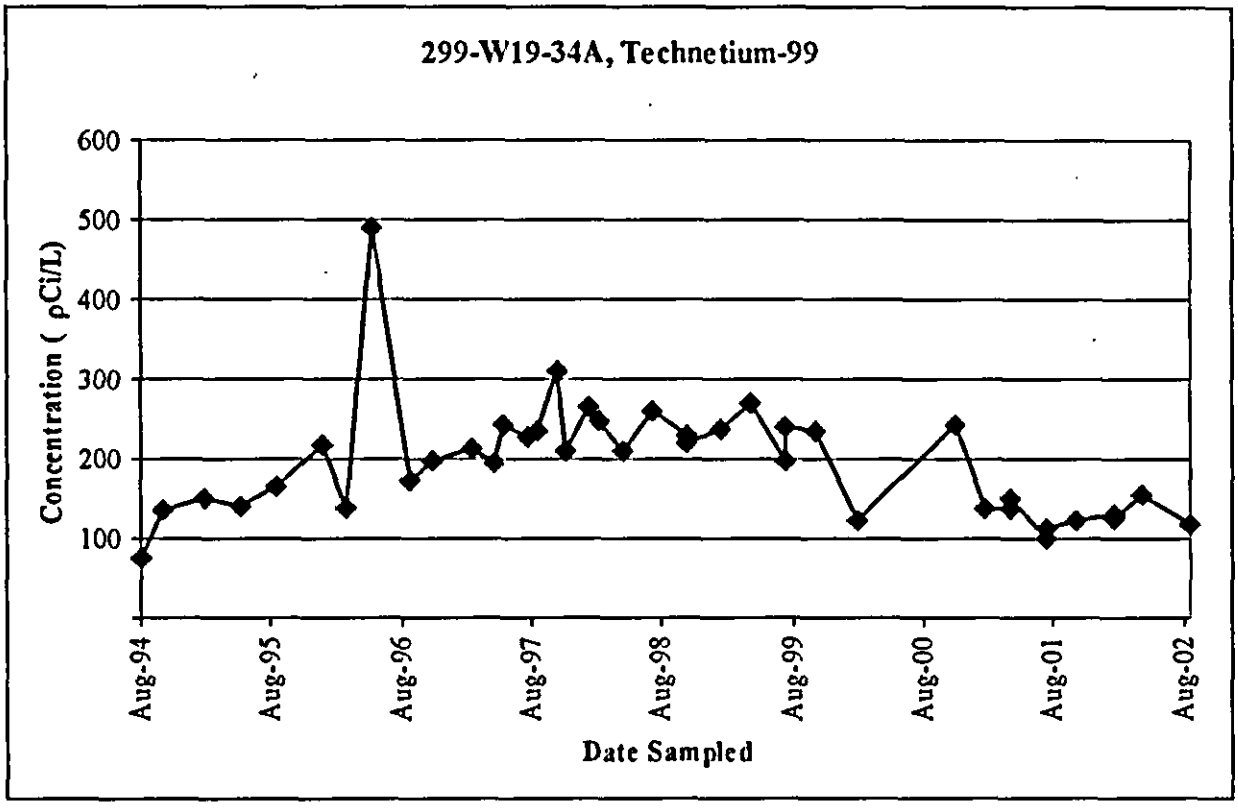

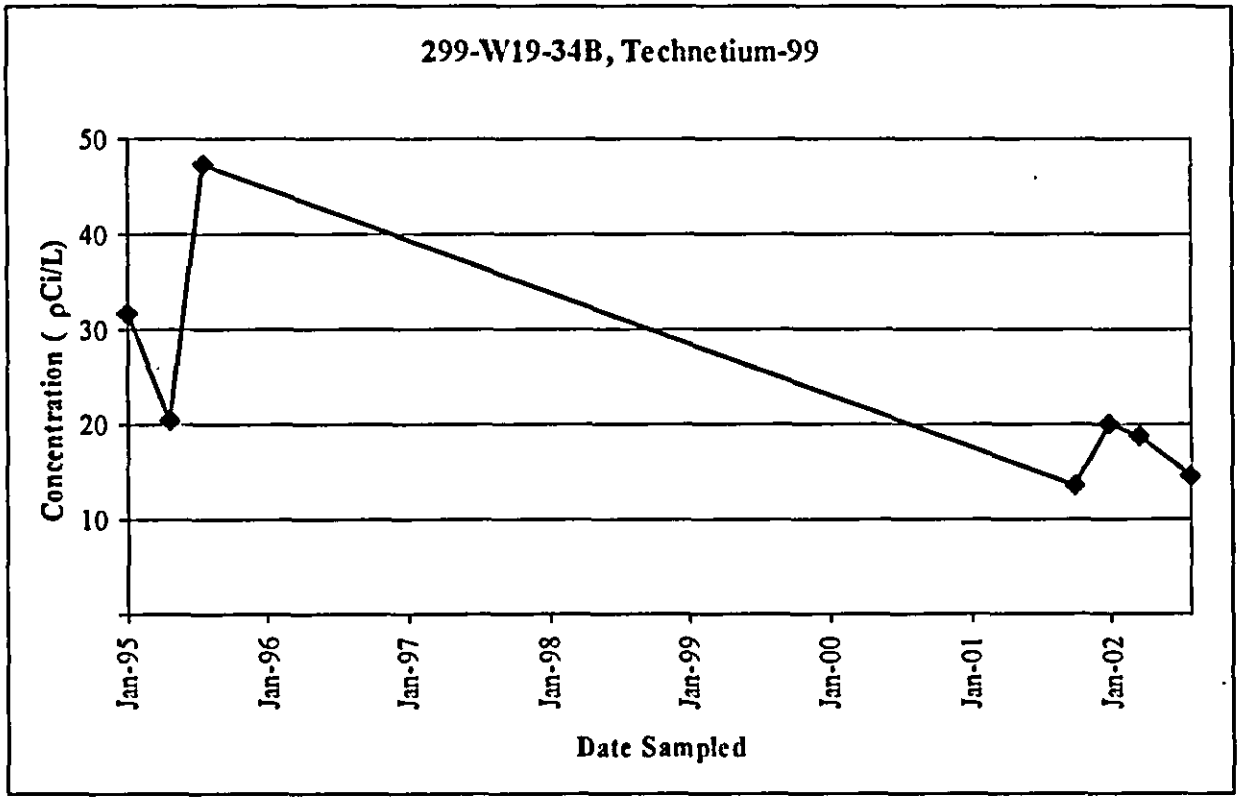

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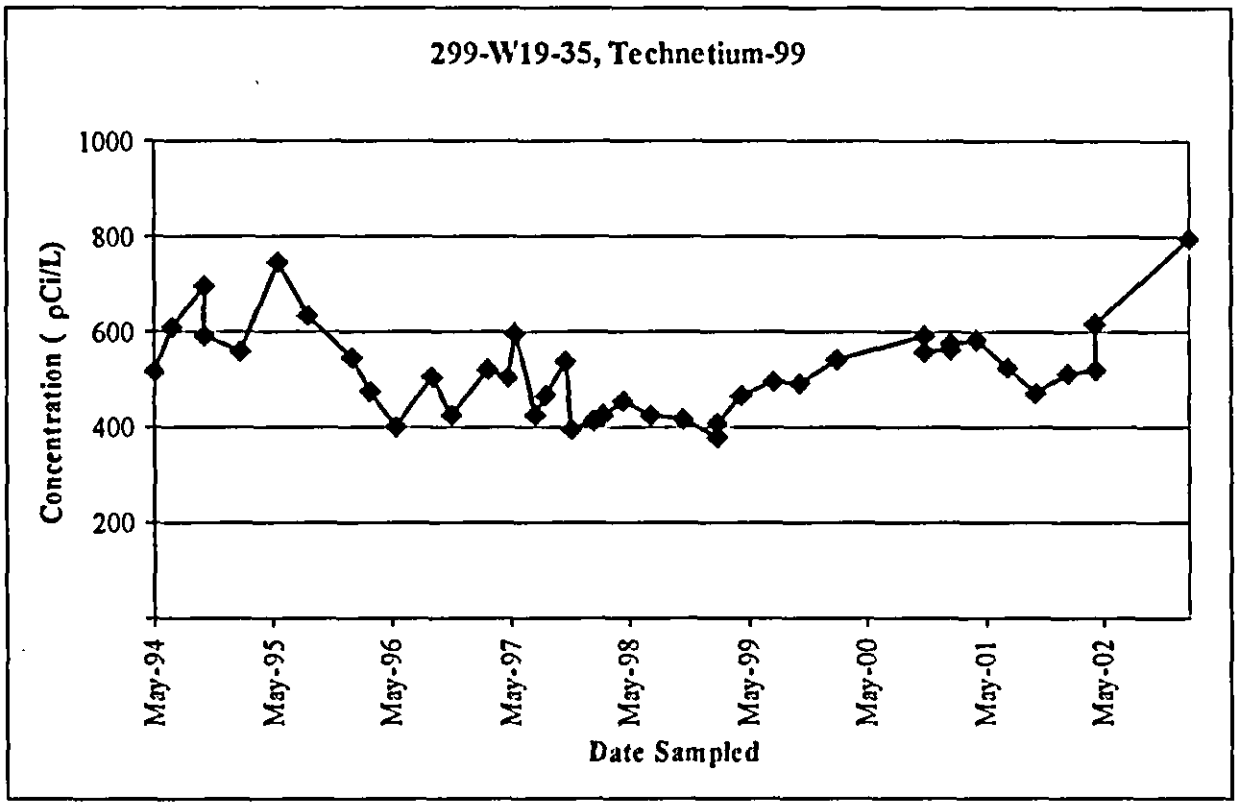

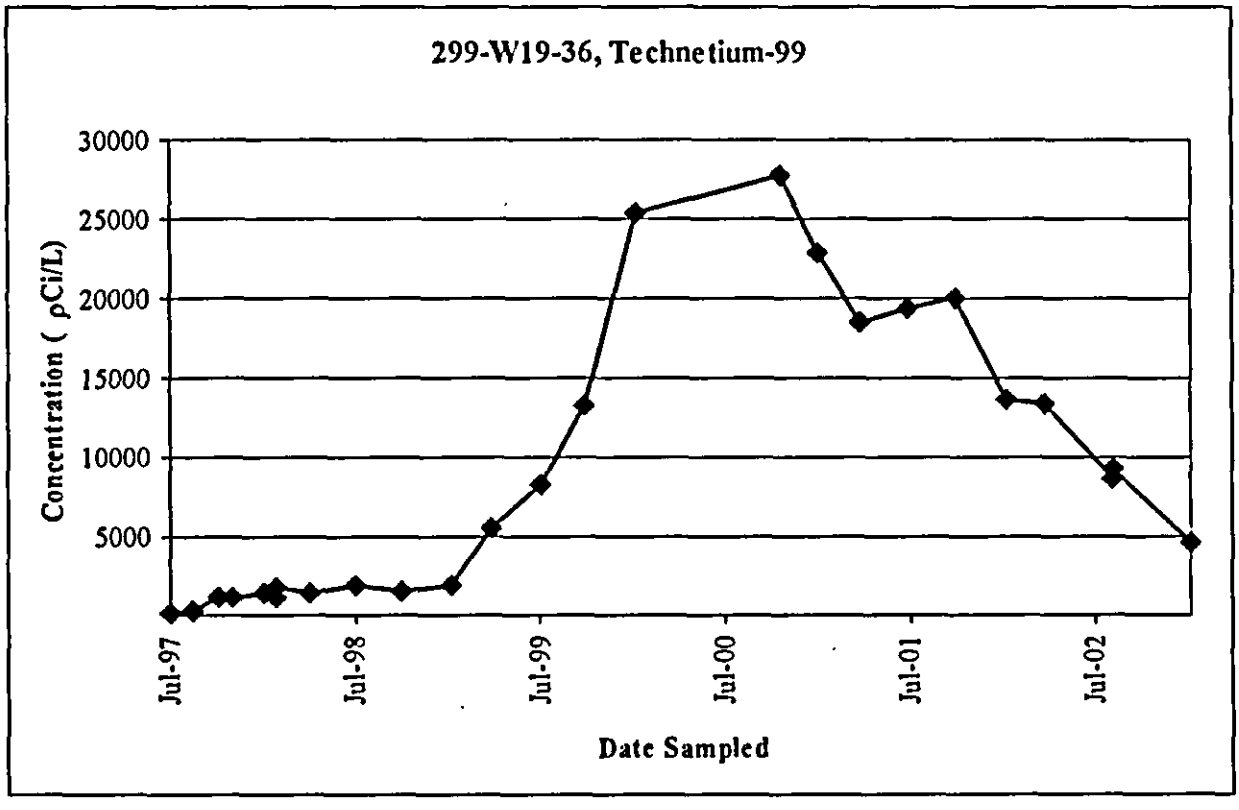

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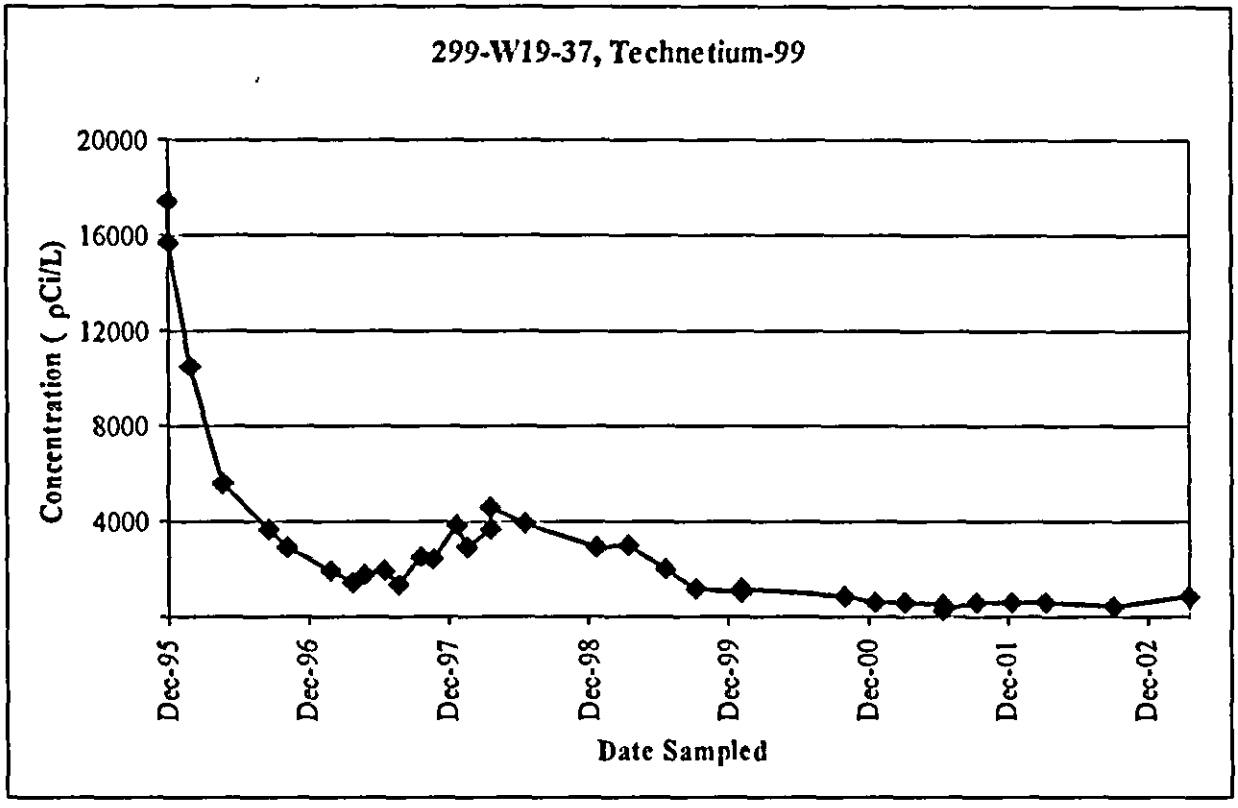

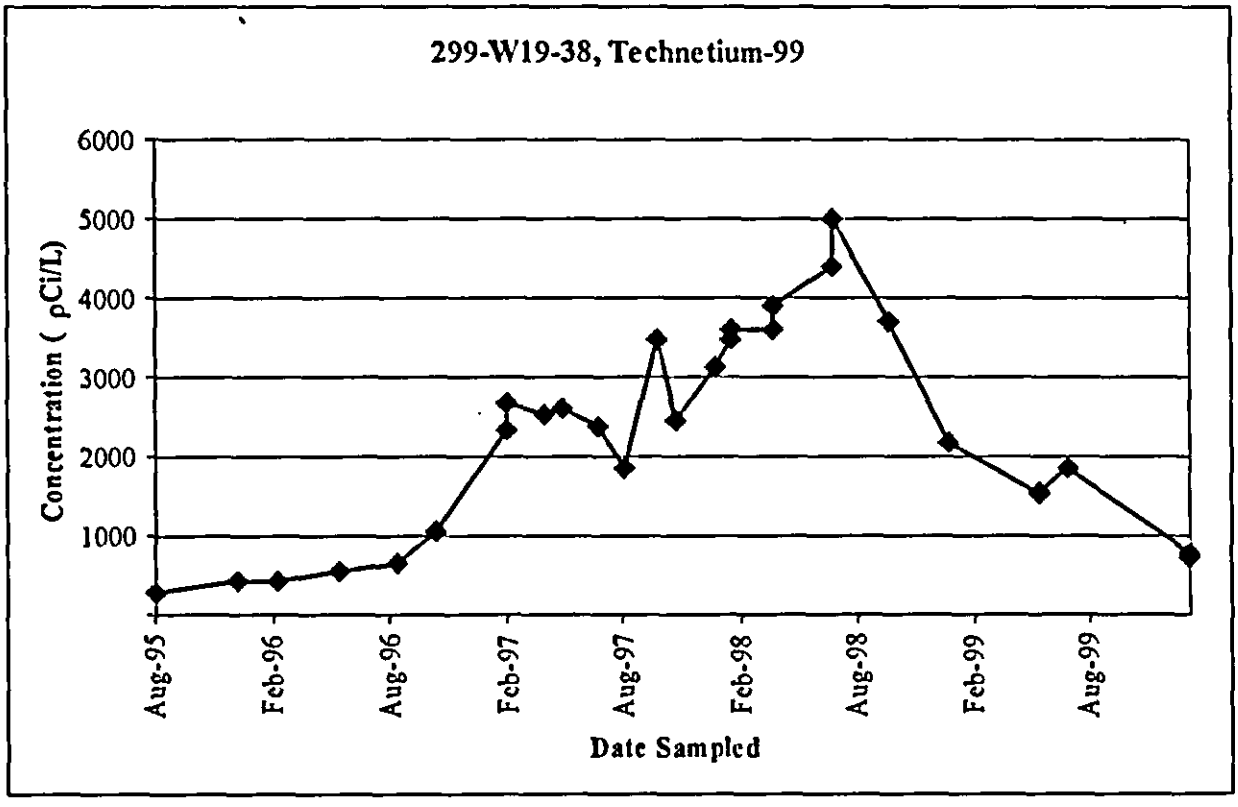

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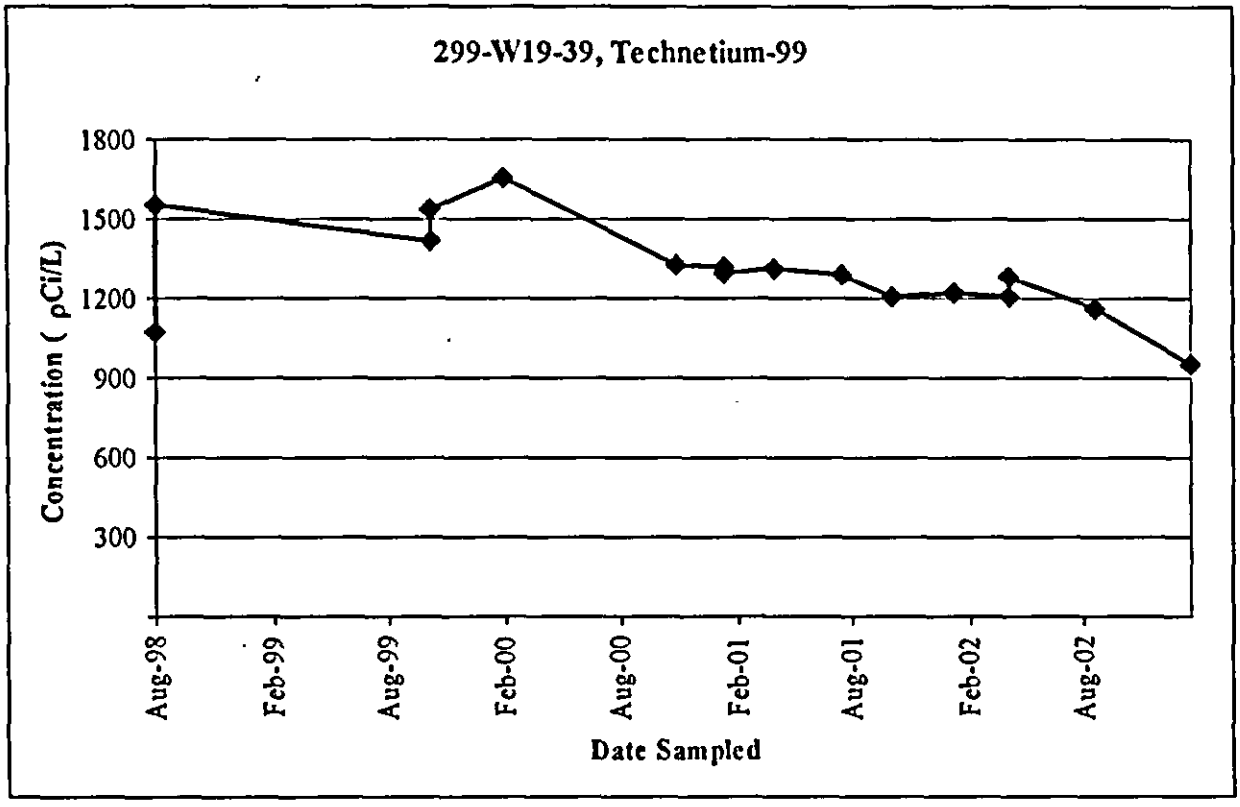

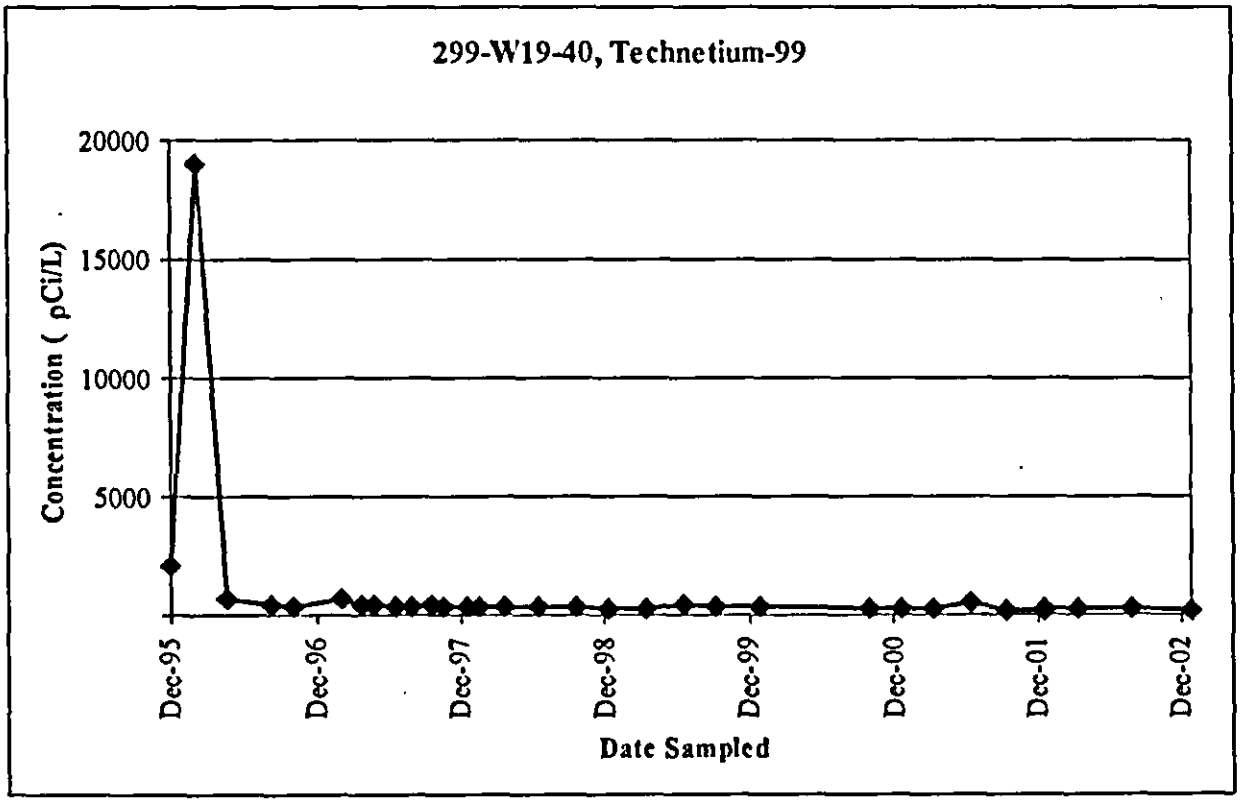

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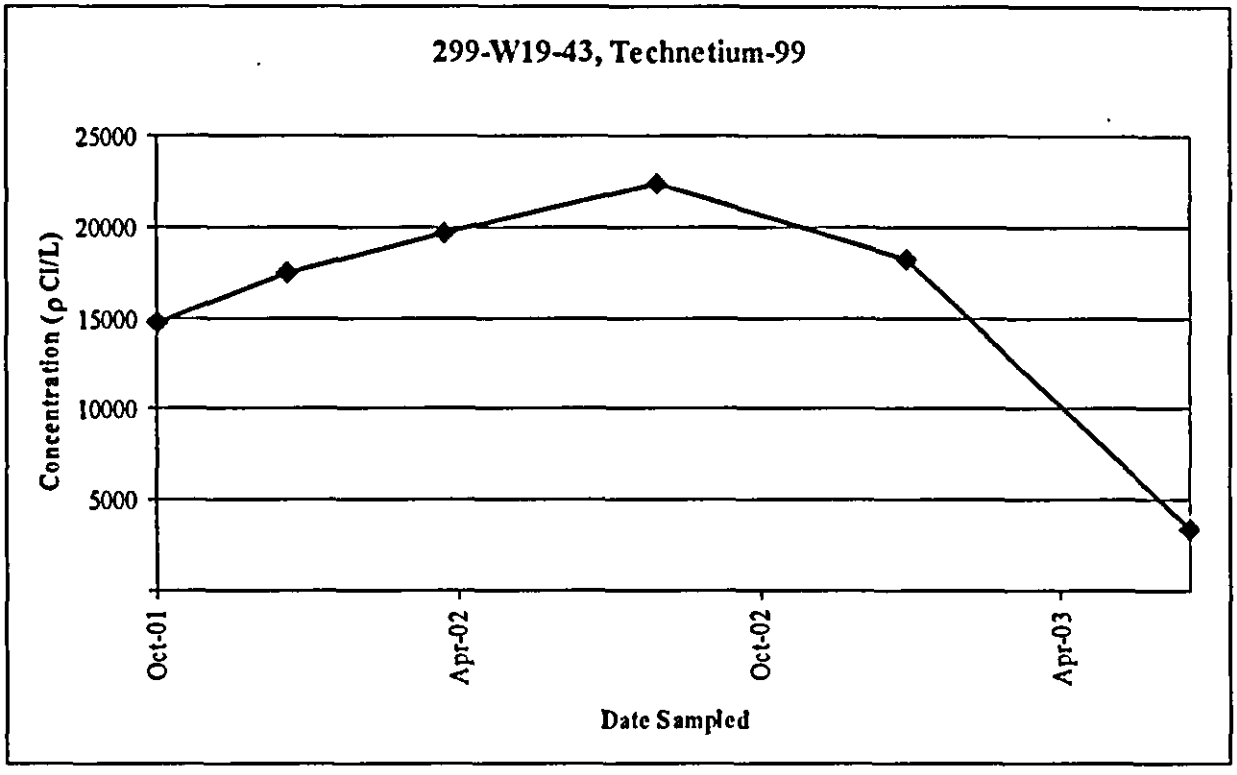

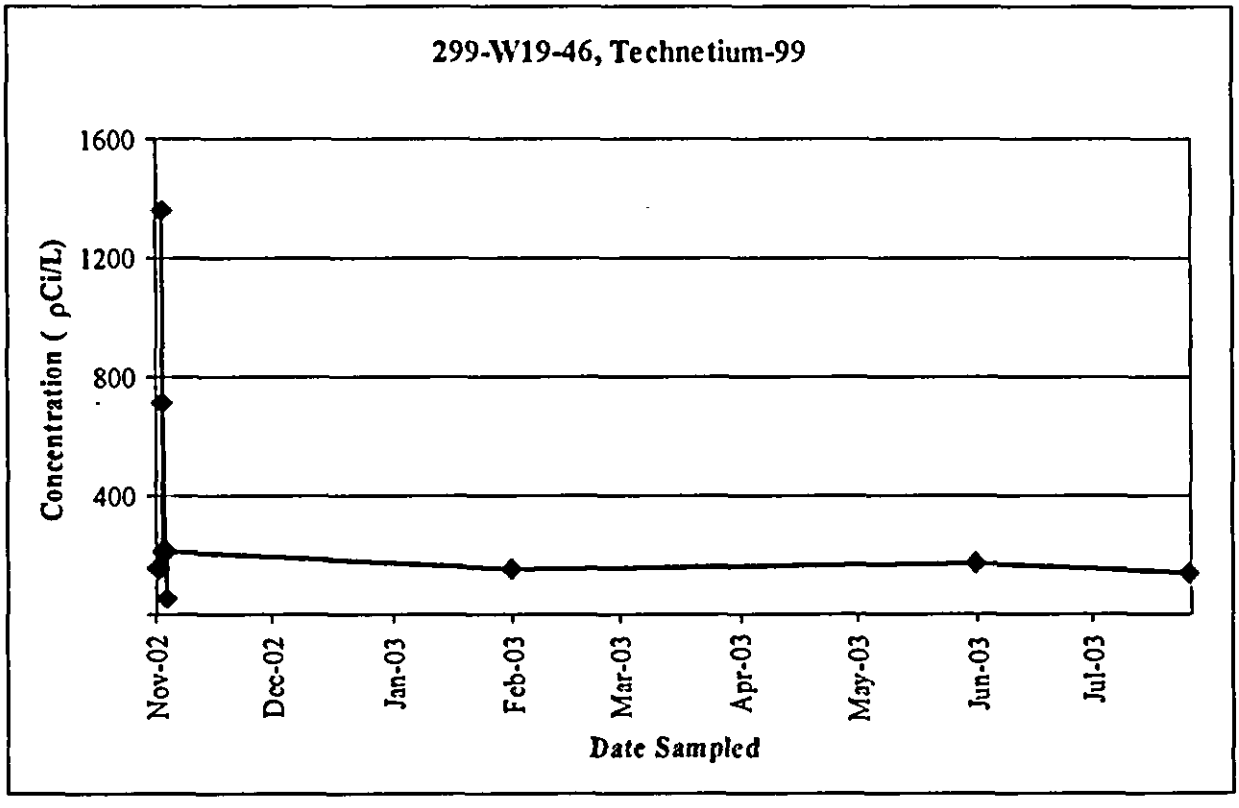

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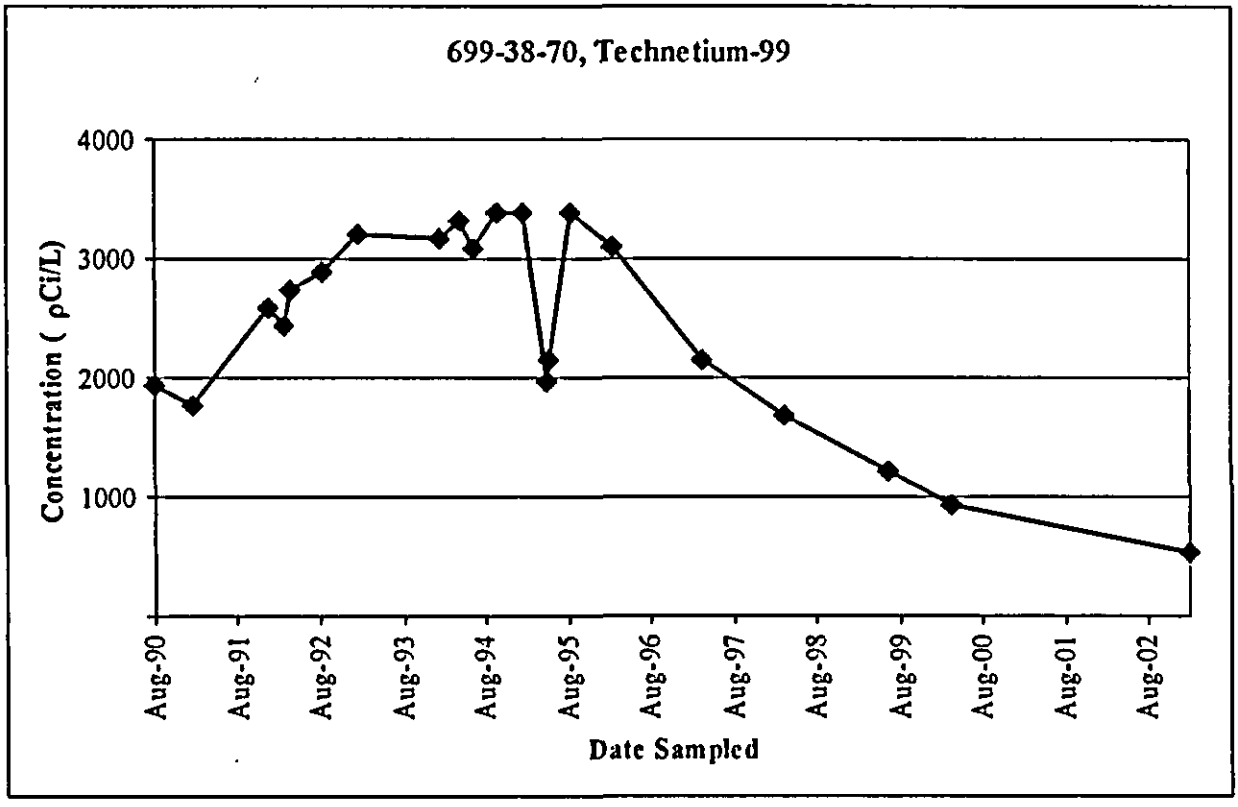

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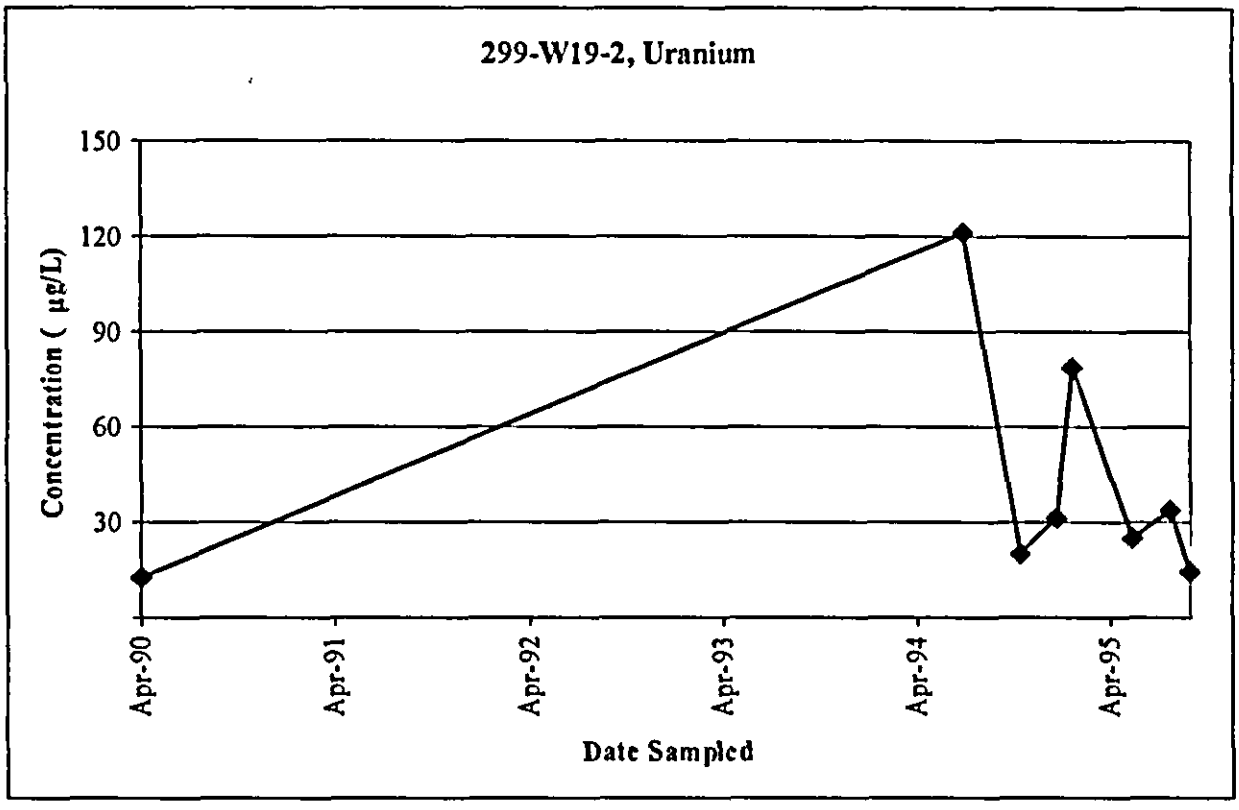

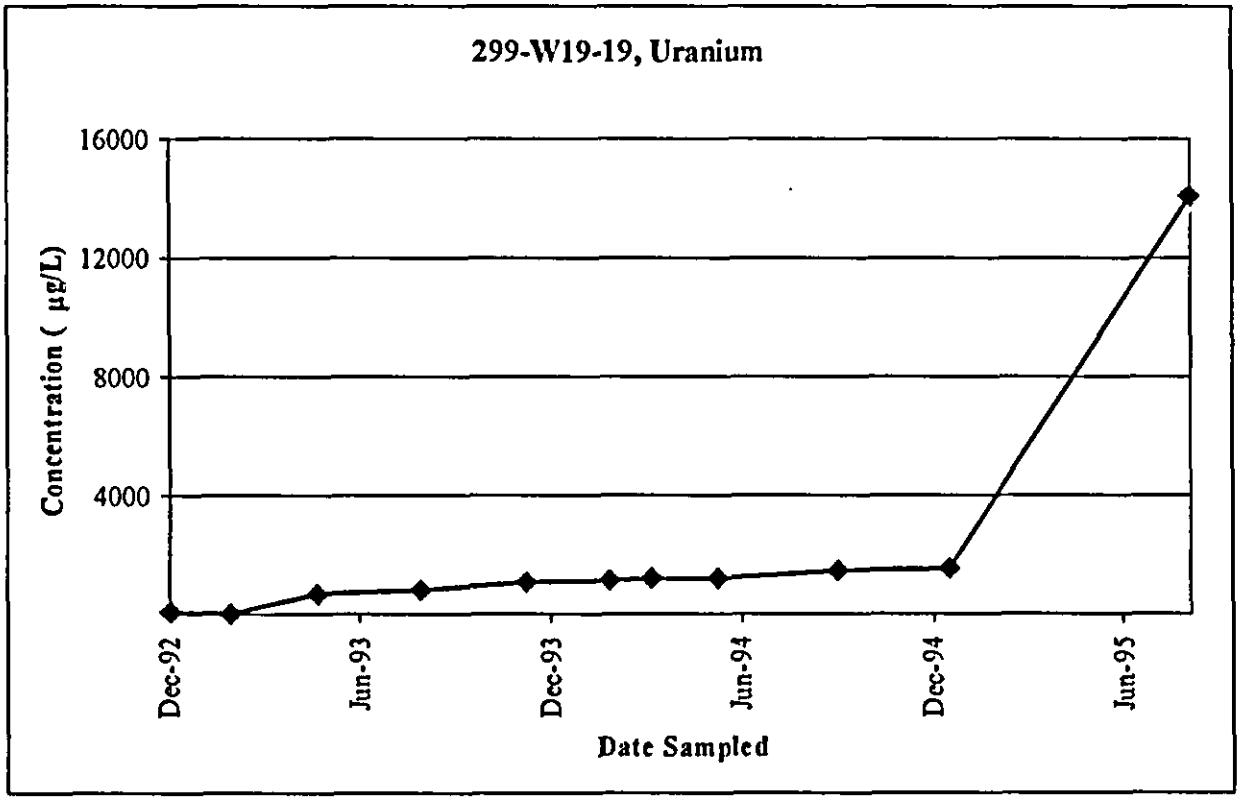

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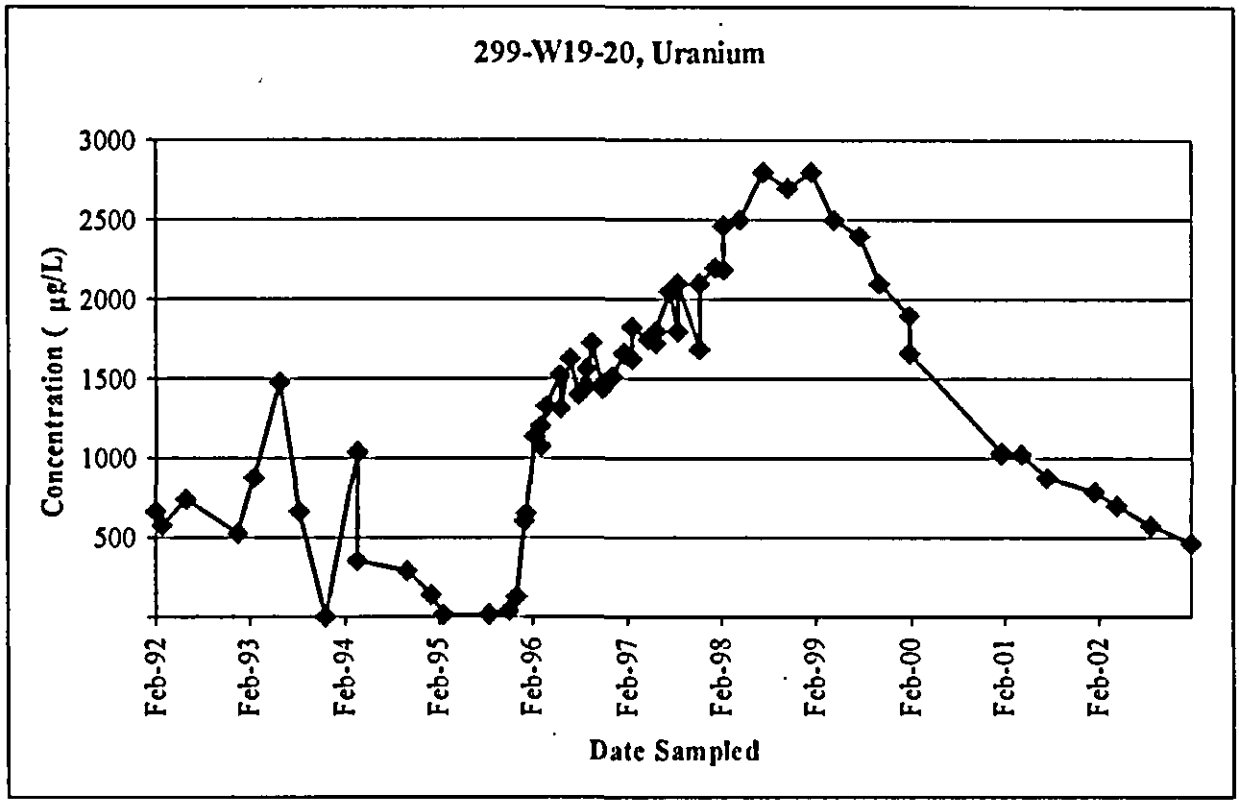

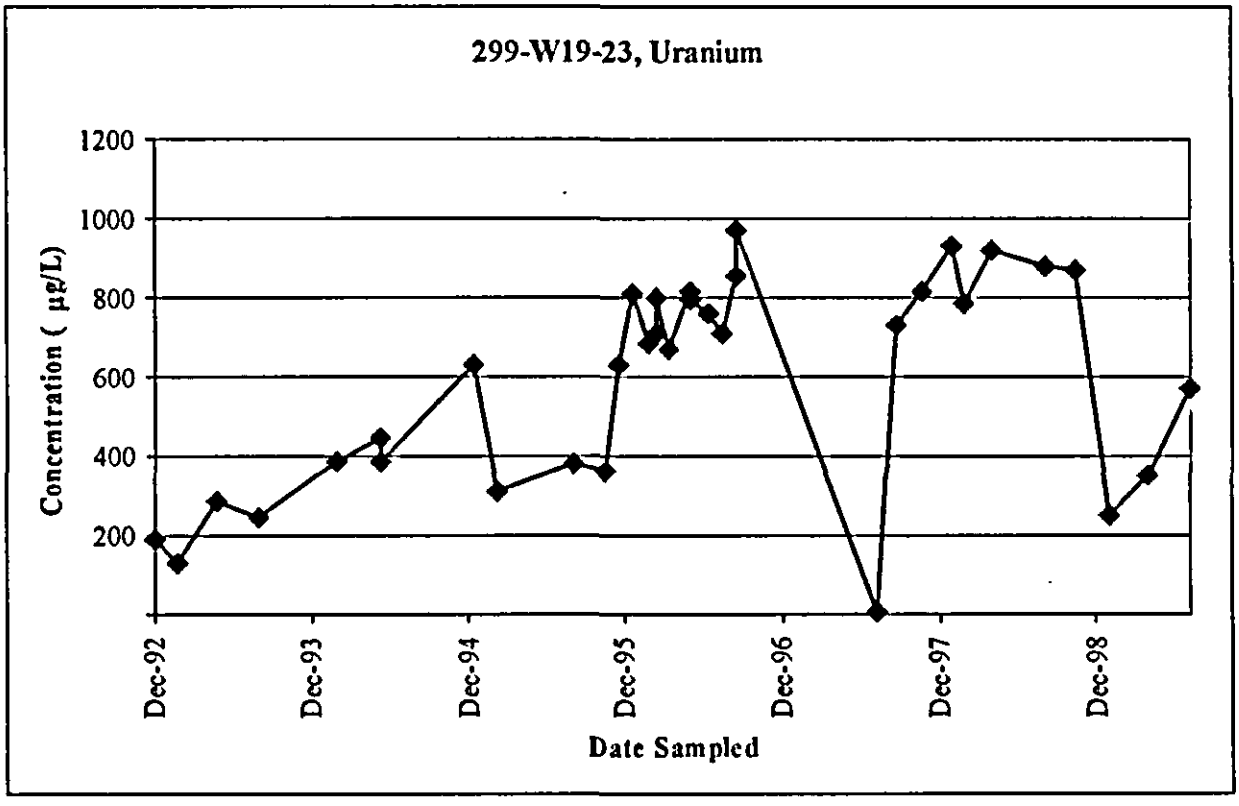

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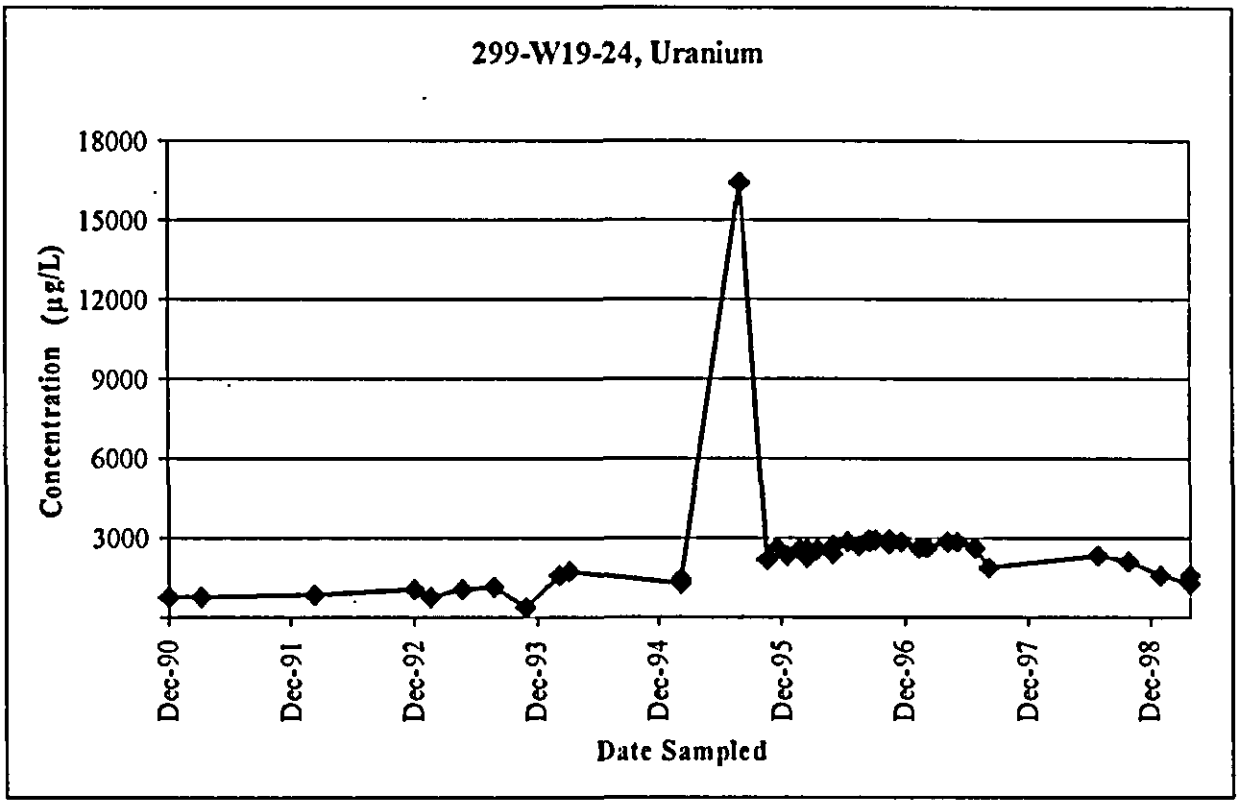

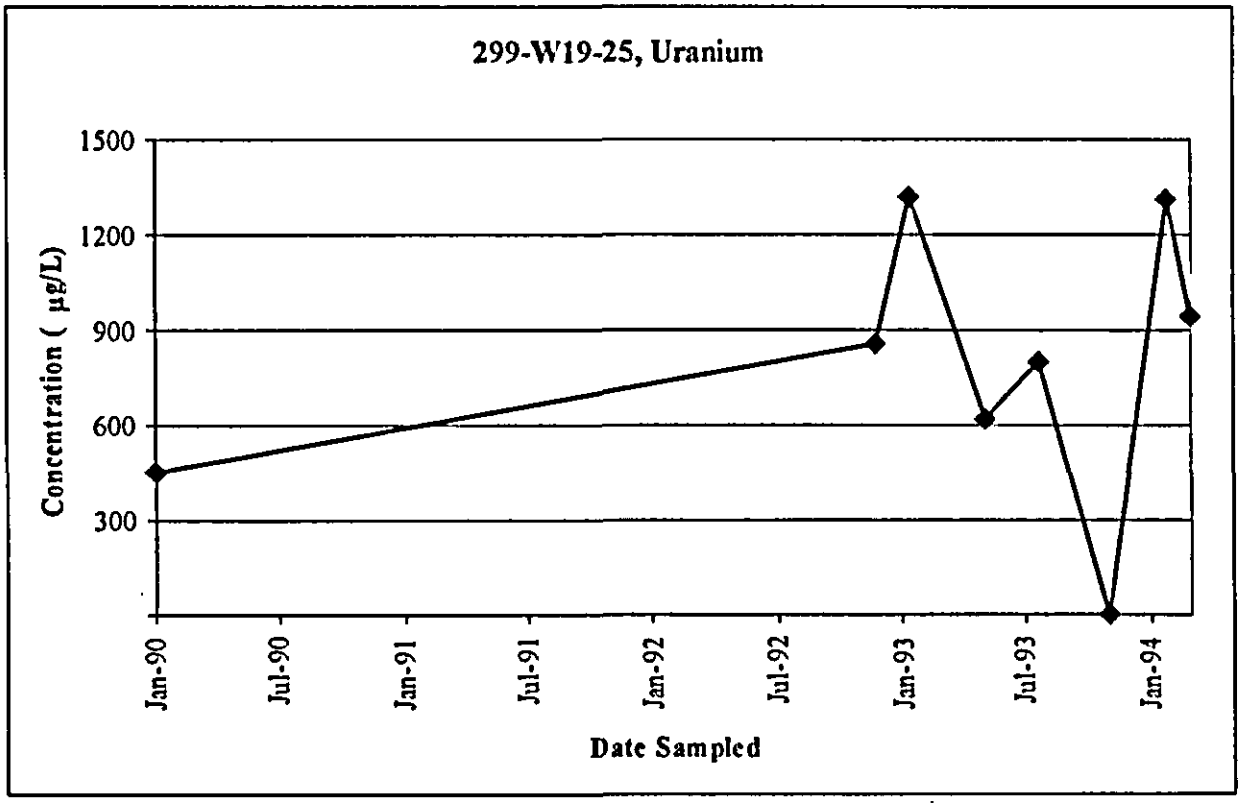

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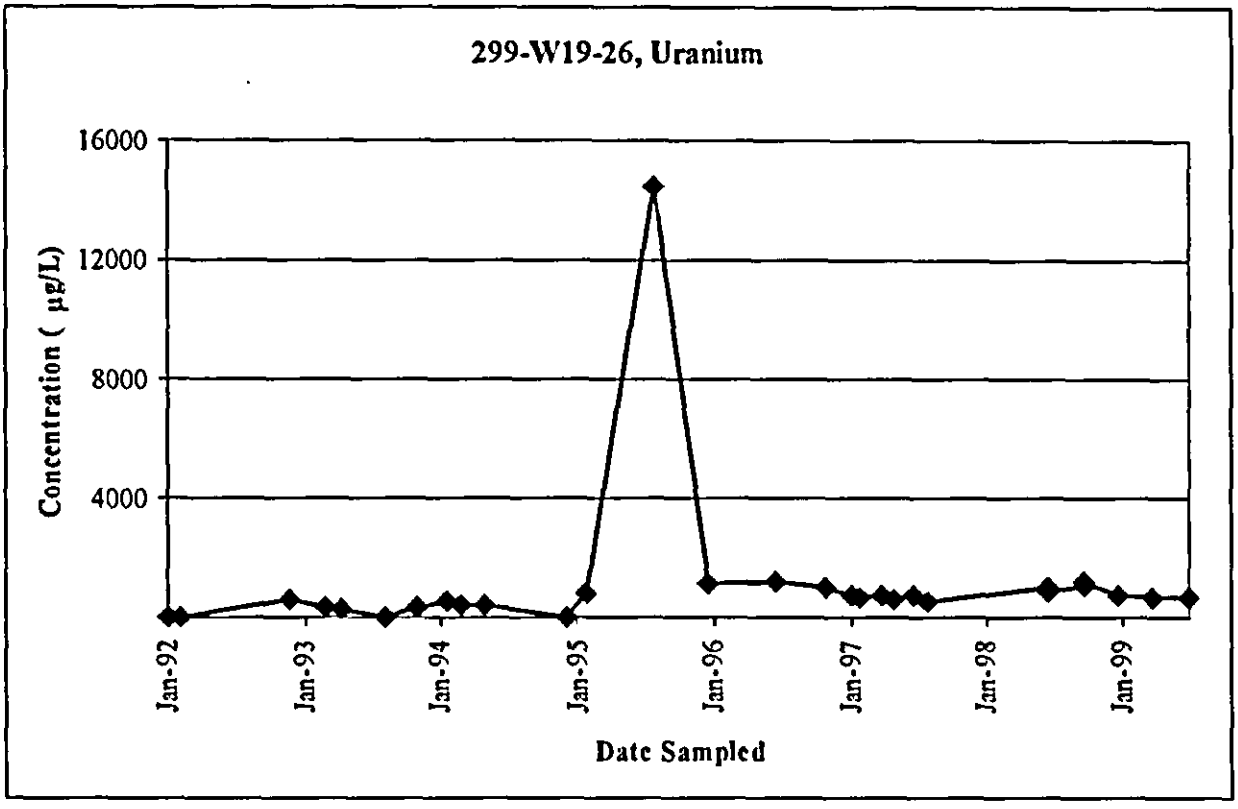

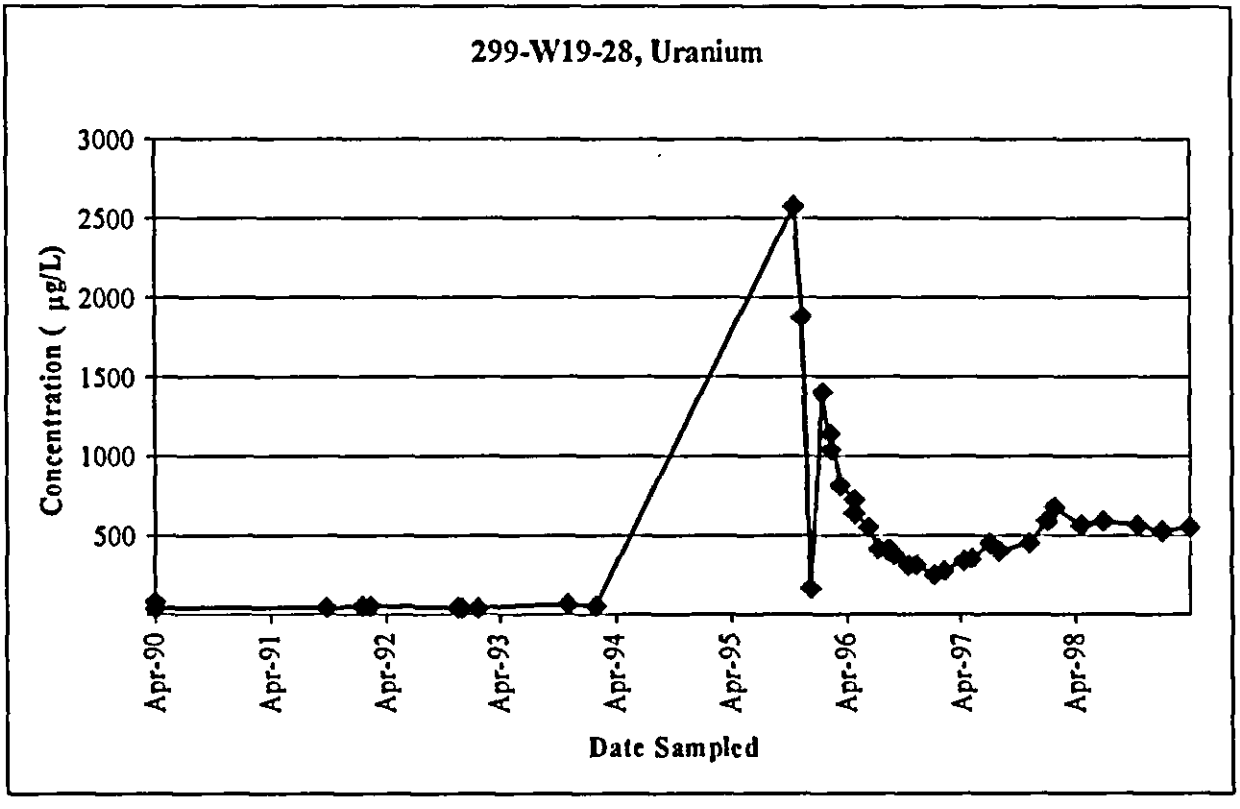

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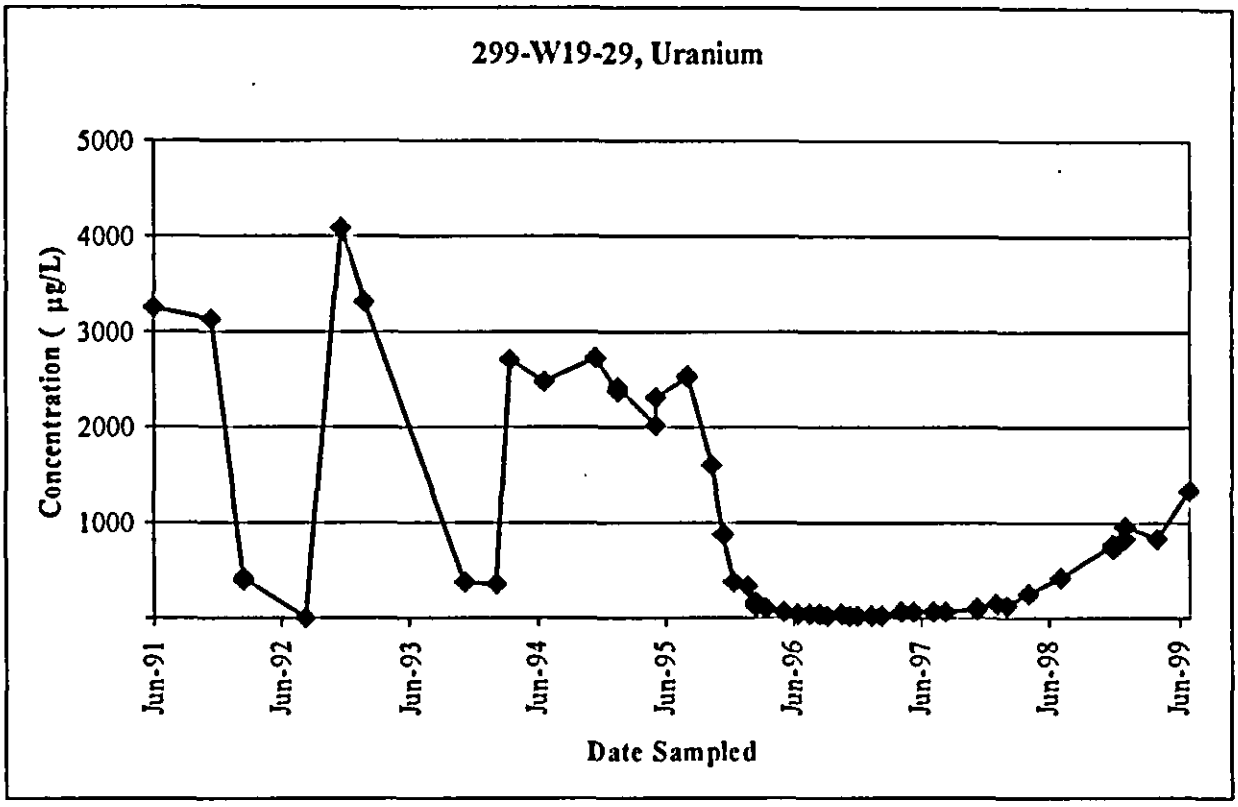

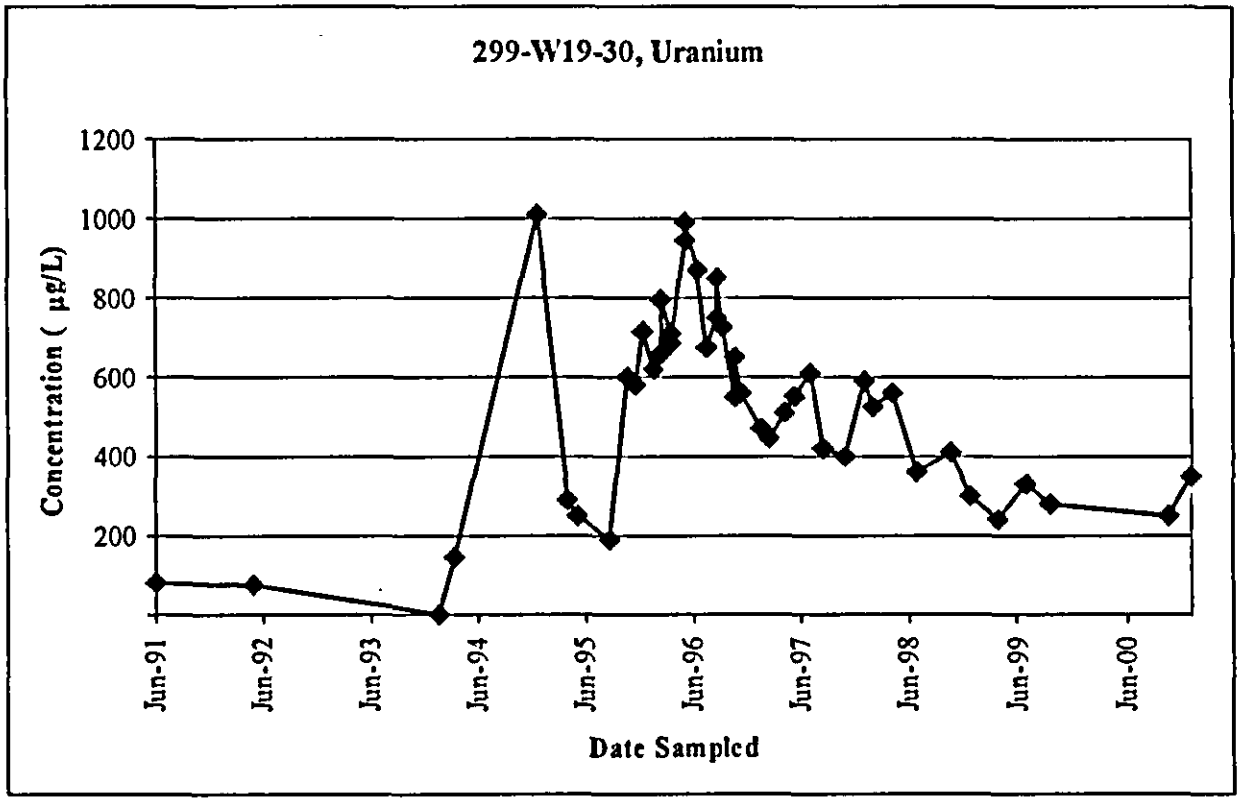

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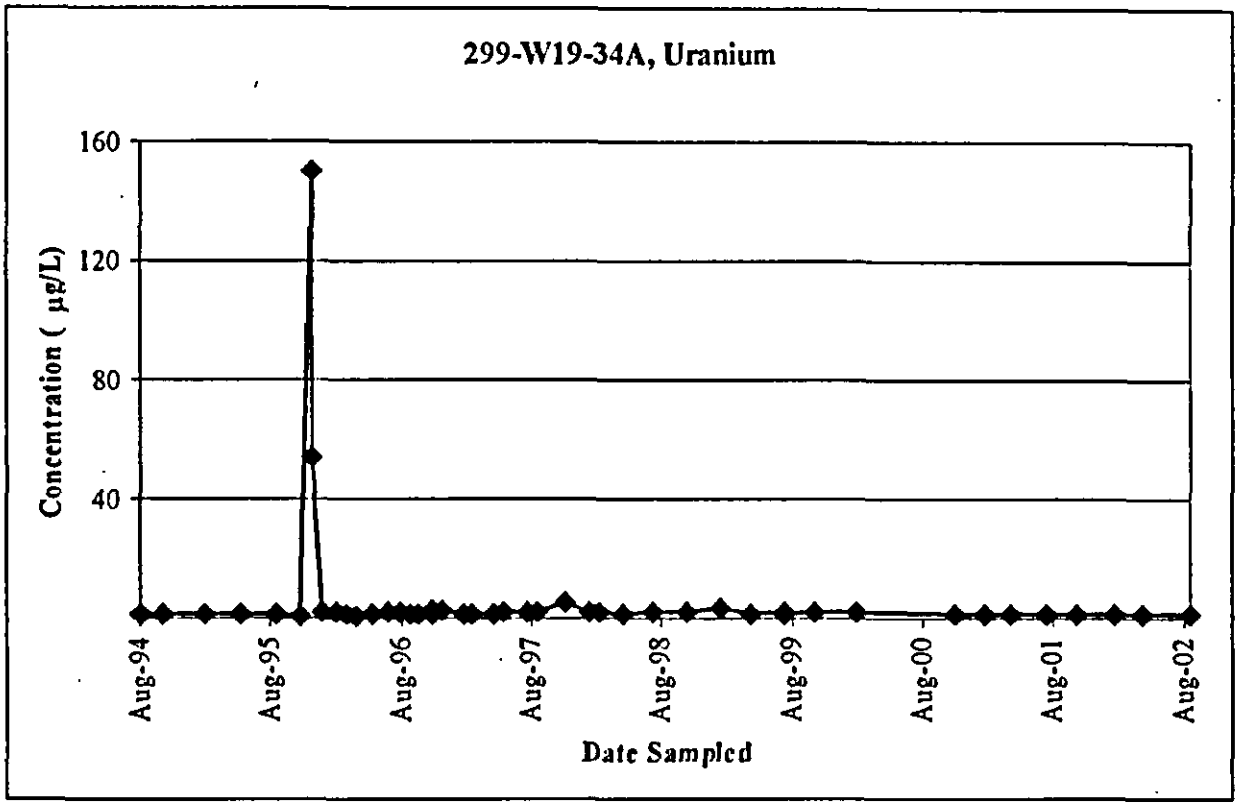

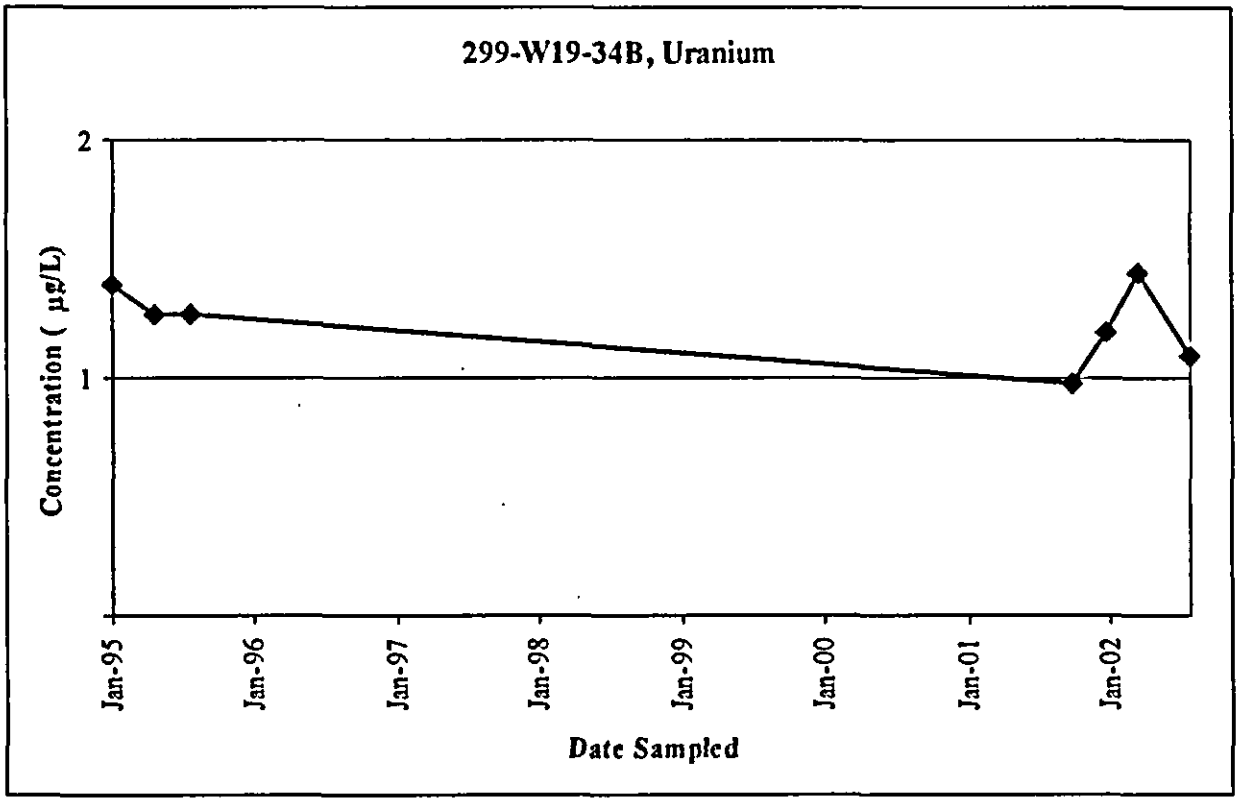

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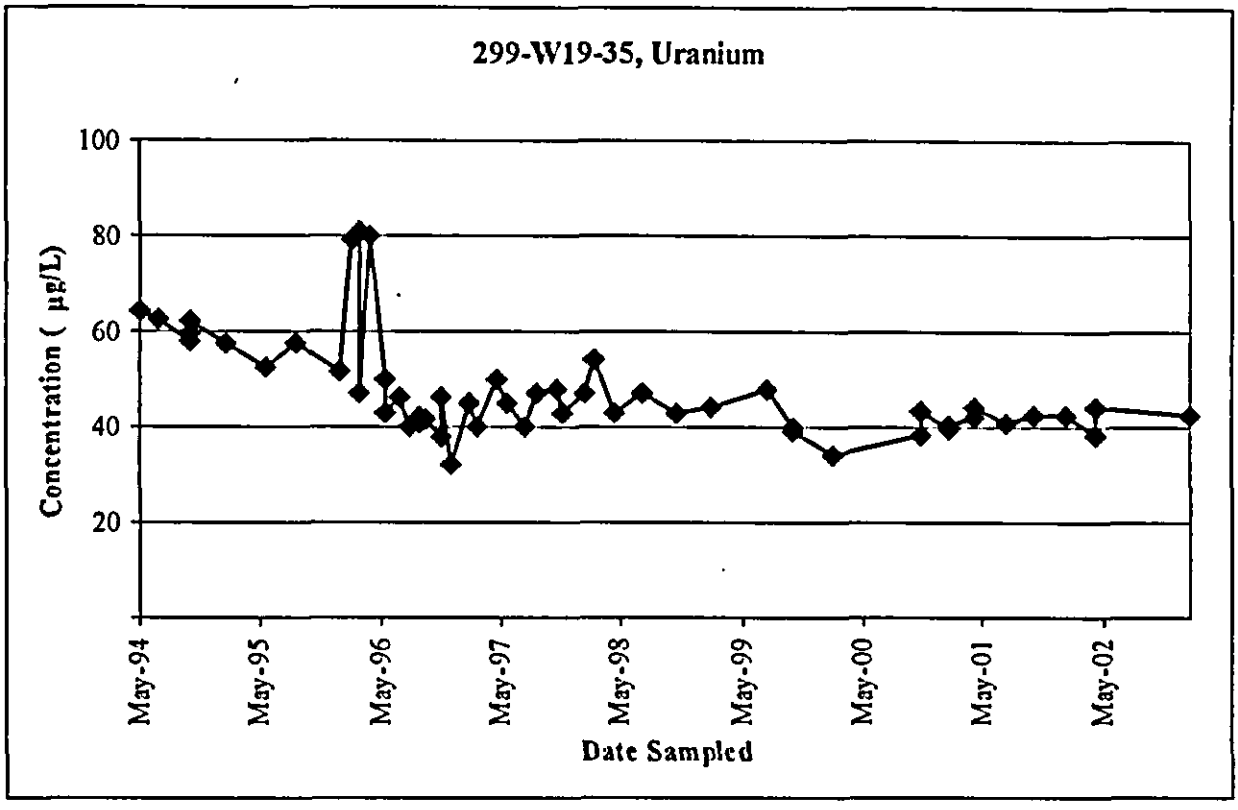


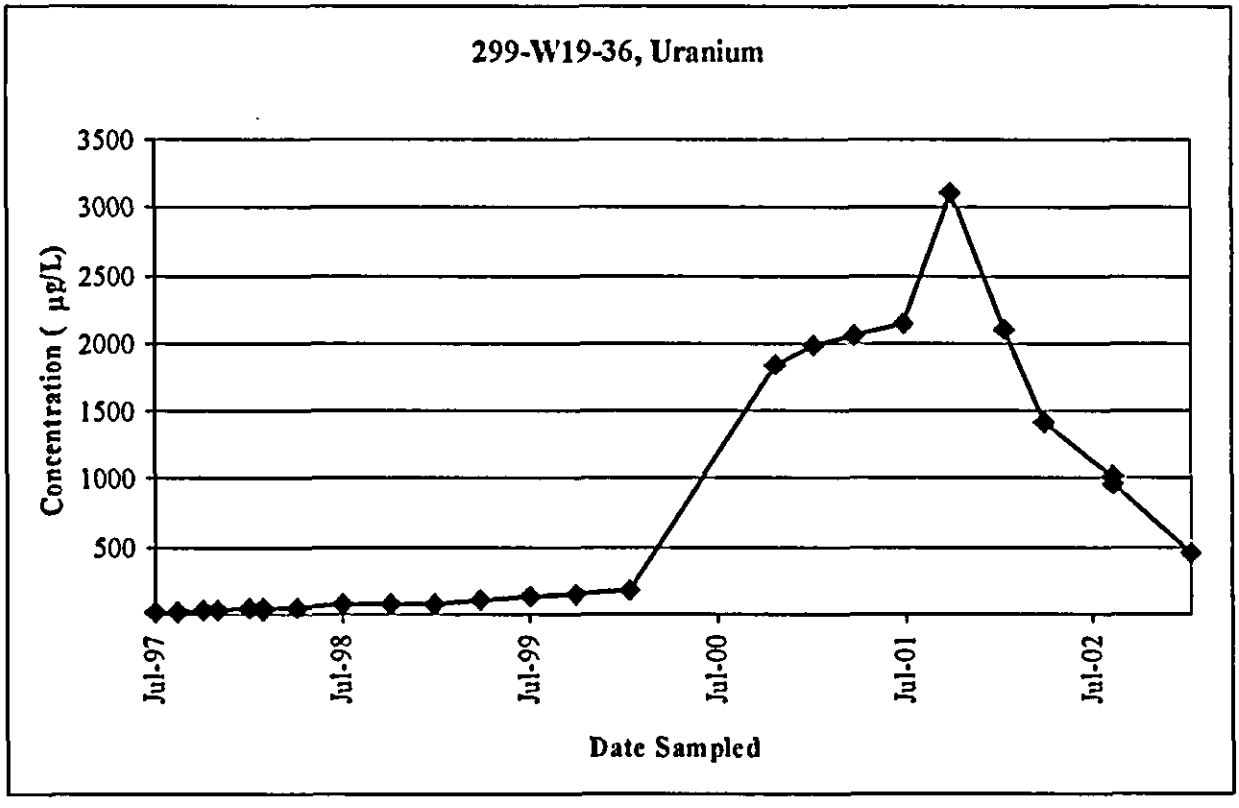
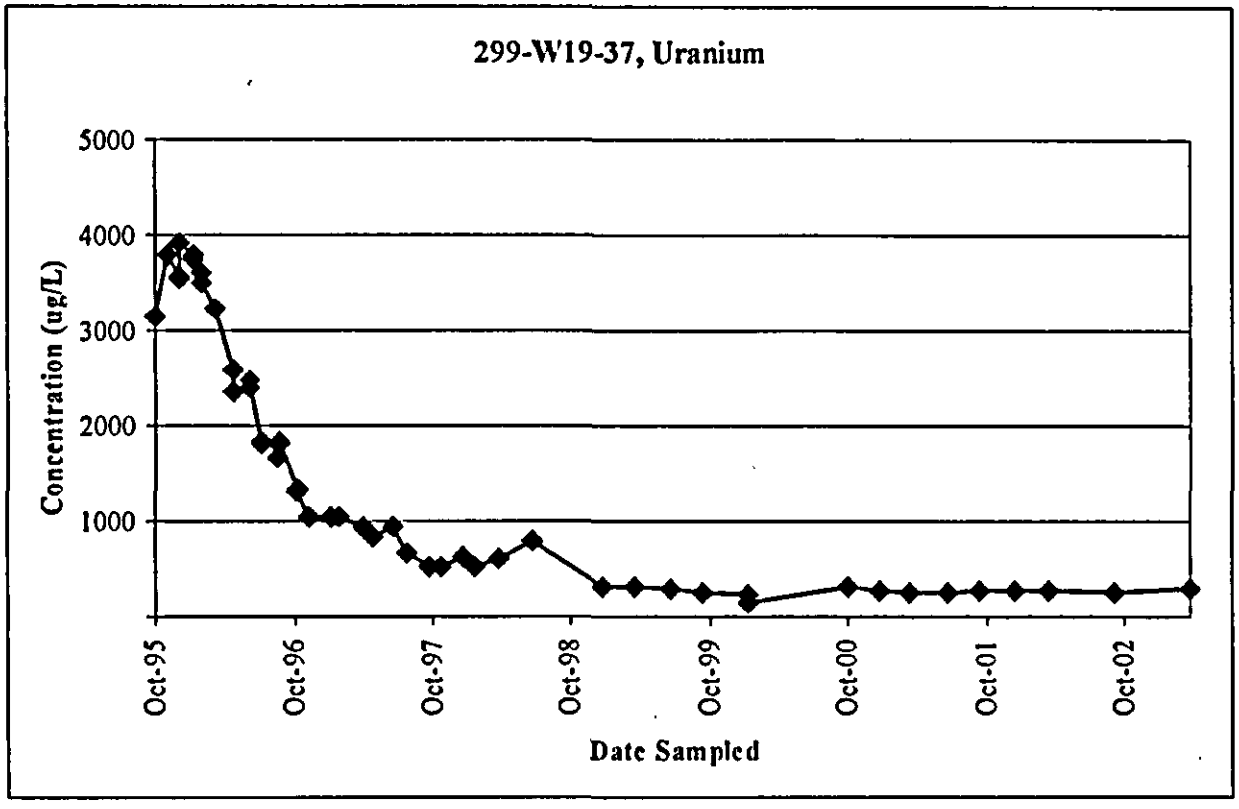
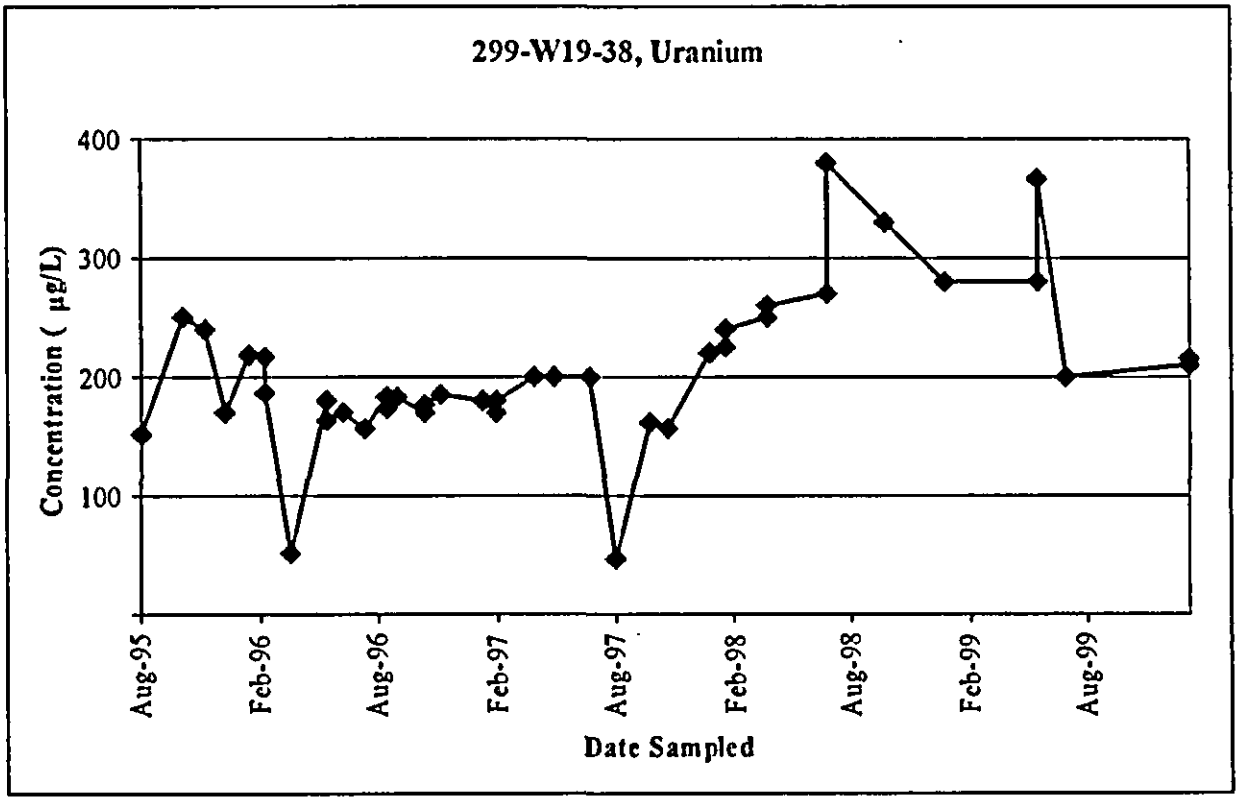


Figure D-2. 200-UP-1 Groundwater Operable Unit, Uranium Concentration Trends at Selected Monitoring Wells. (11 sheets)





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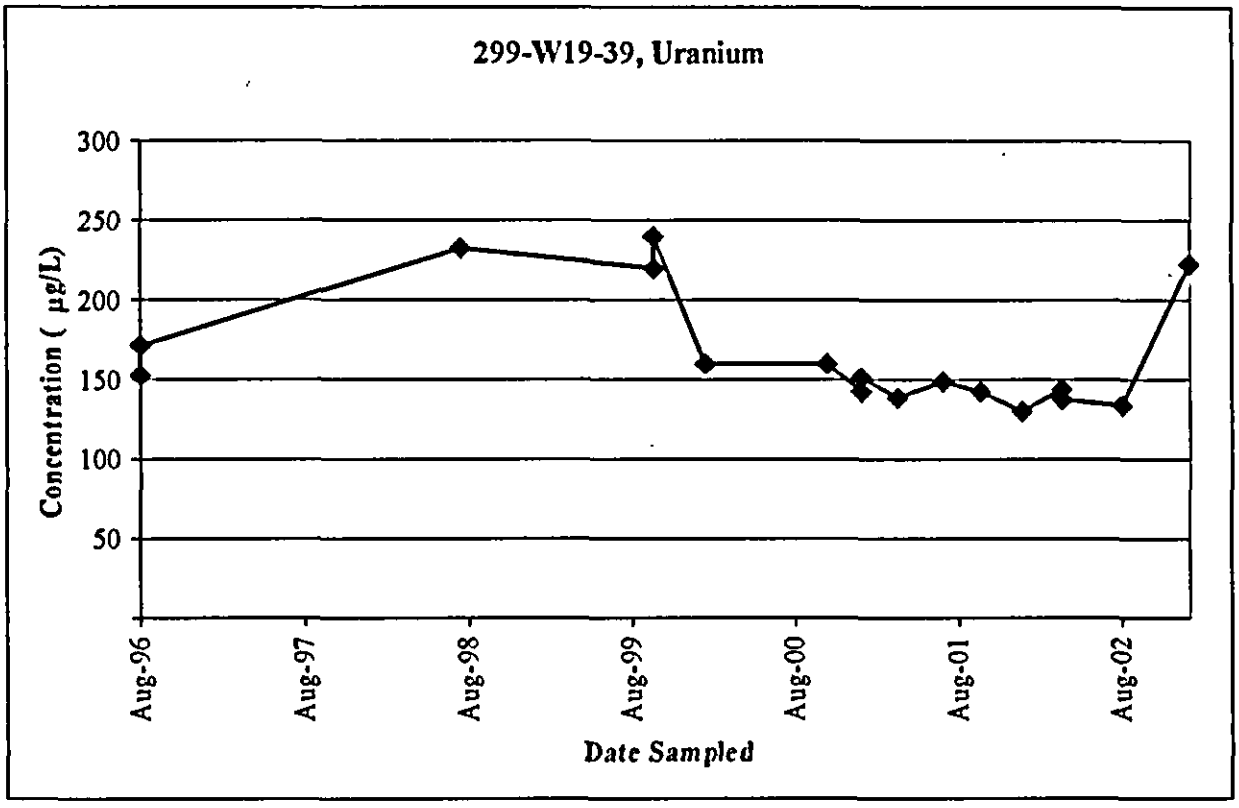

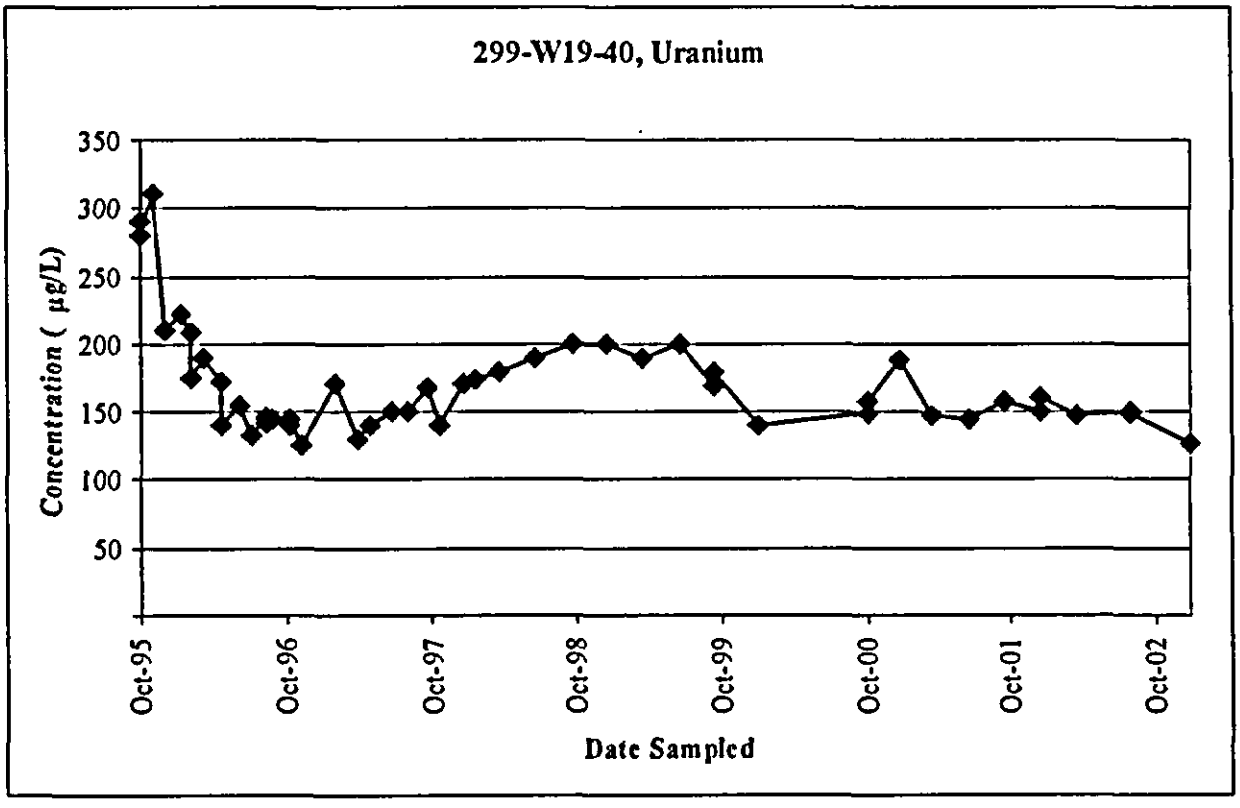

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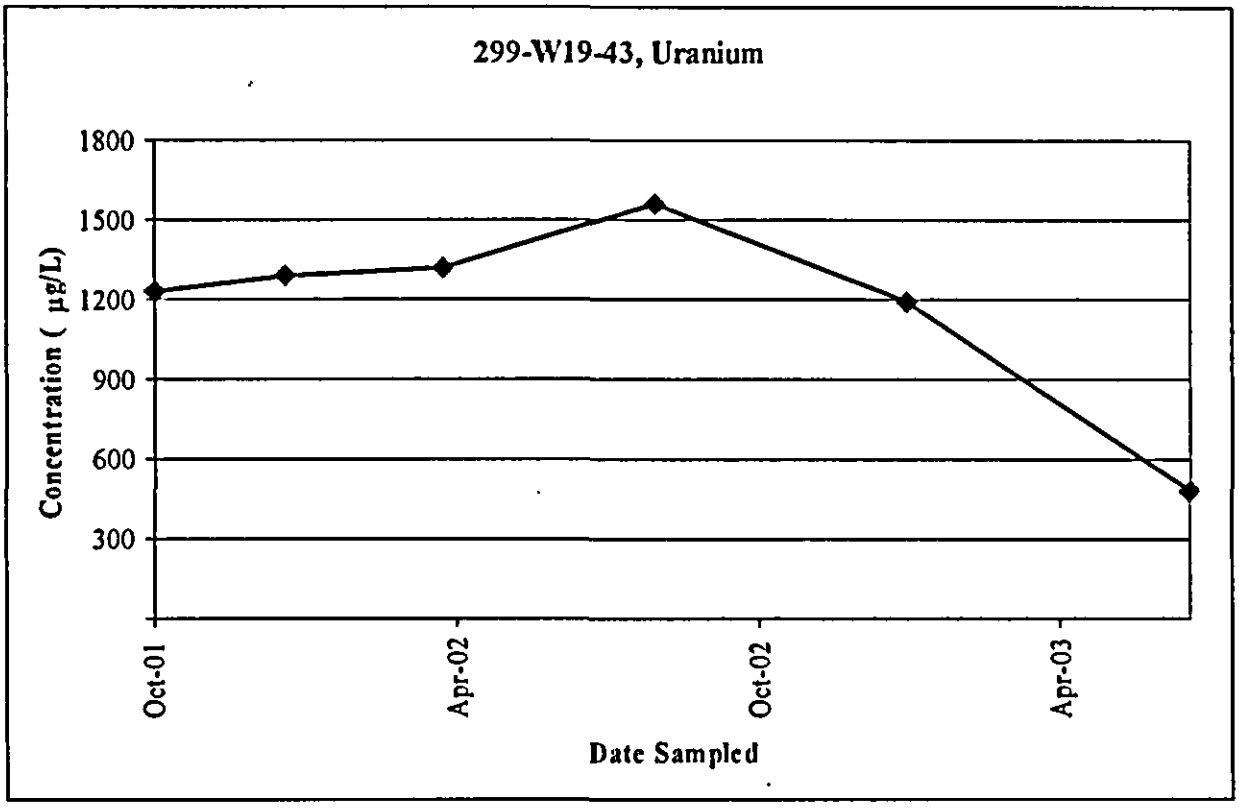

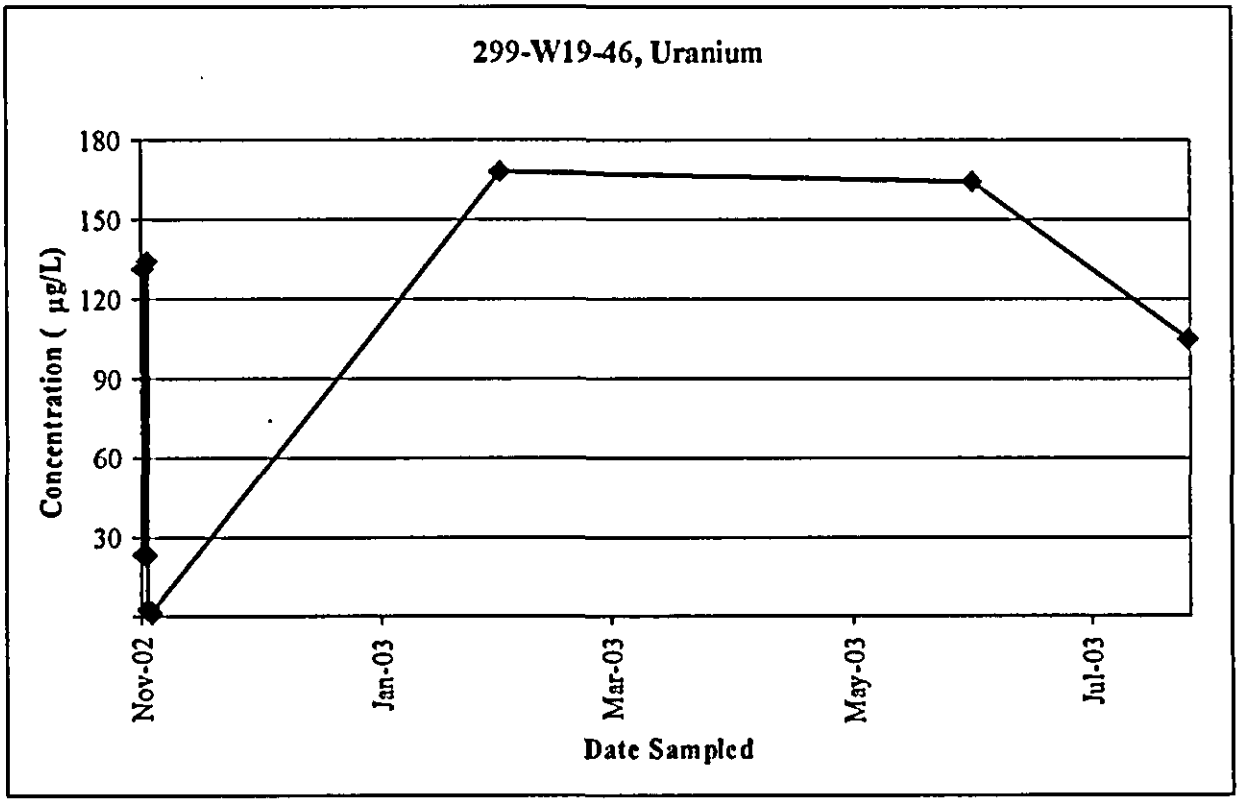

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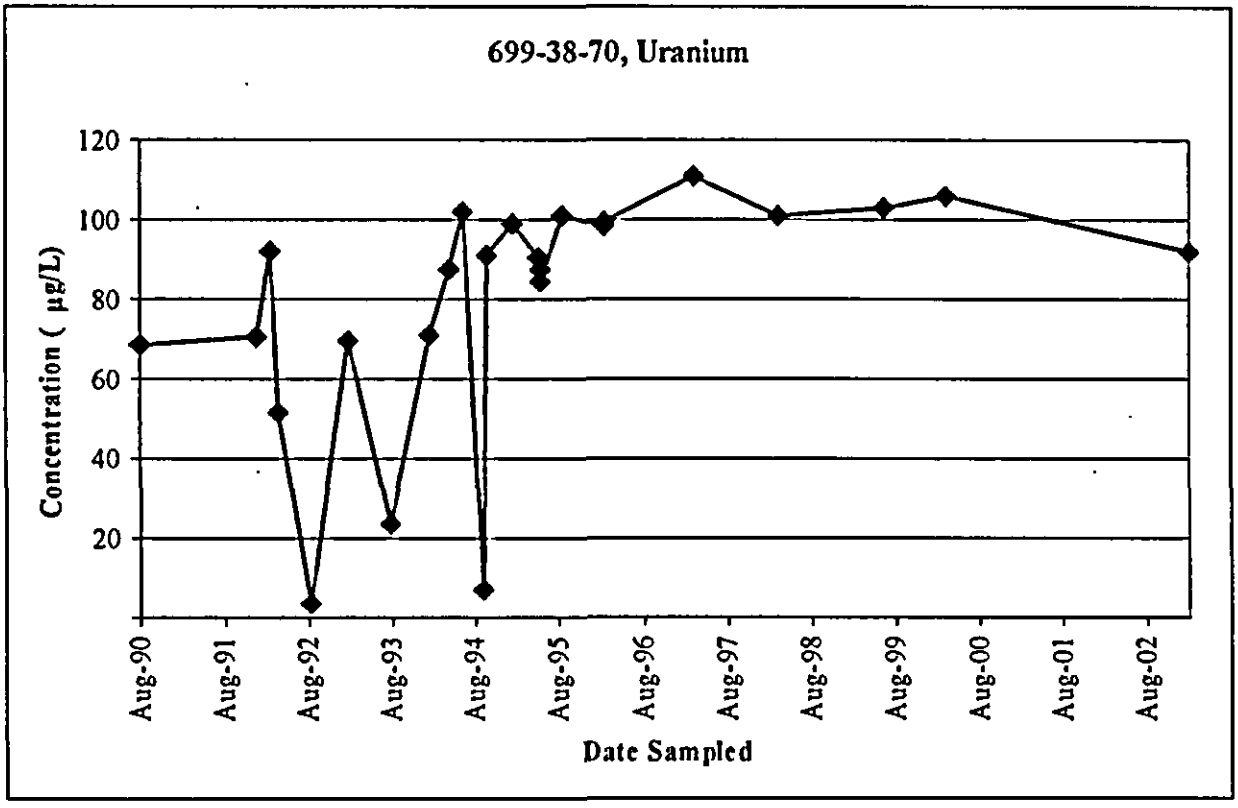
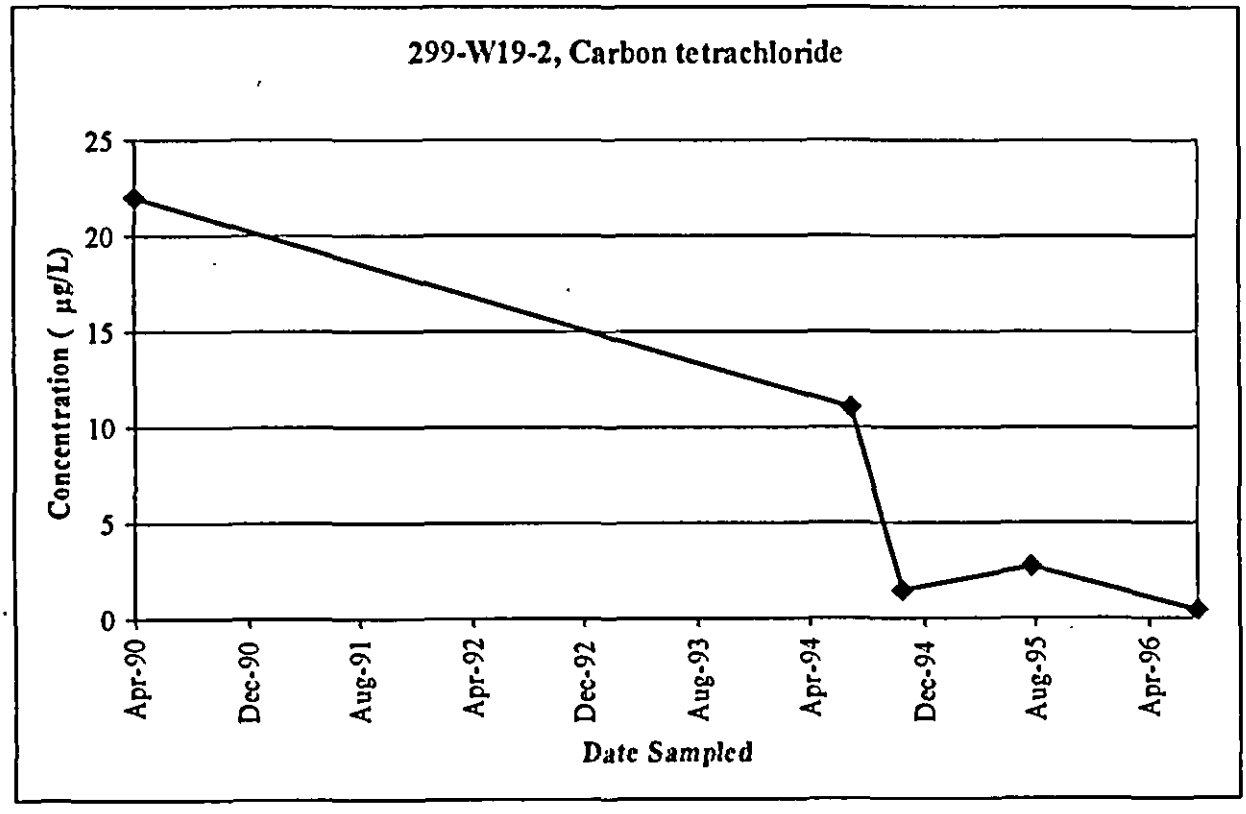
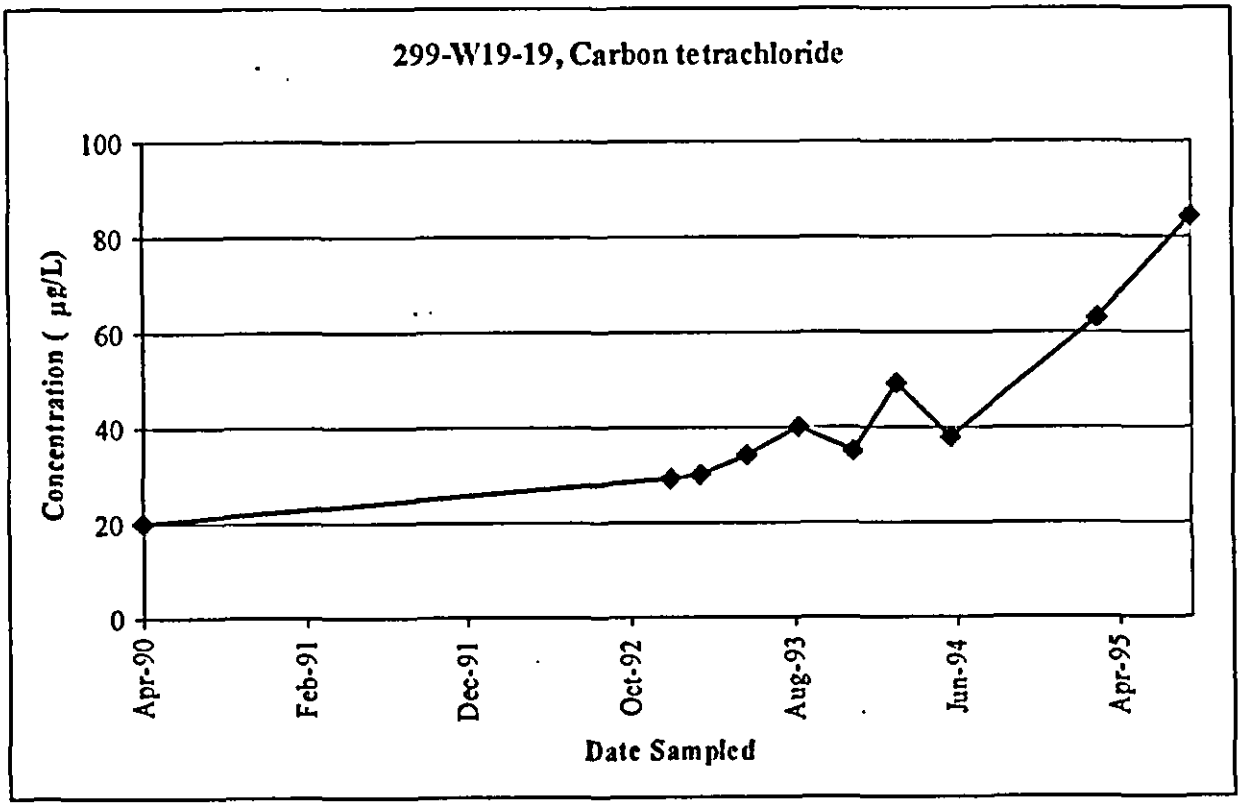


Figure D-3. 200-UP-1 Groundwater Operable Unit, Carbon Tetrachloride Concentration Trends at Selected Monitoring Wells. (11 sheets)





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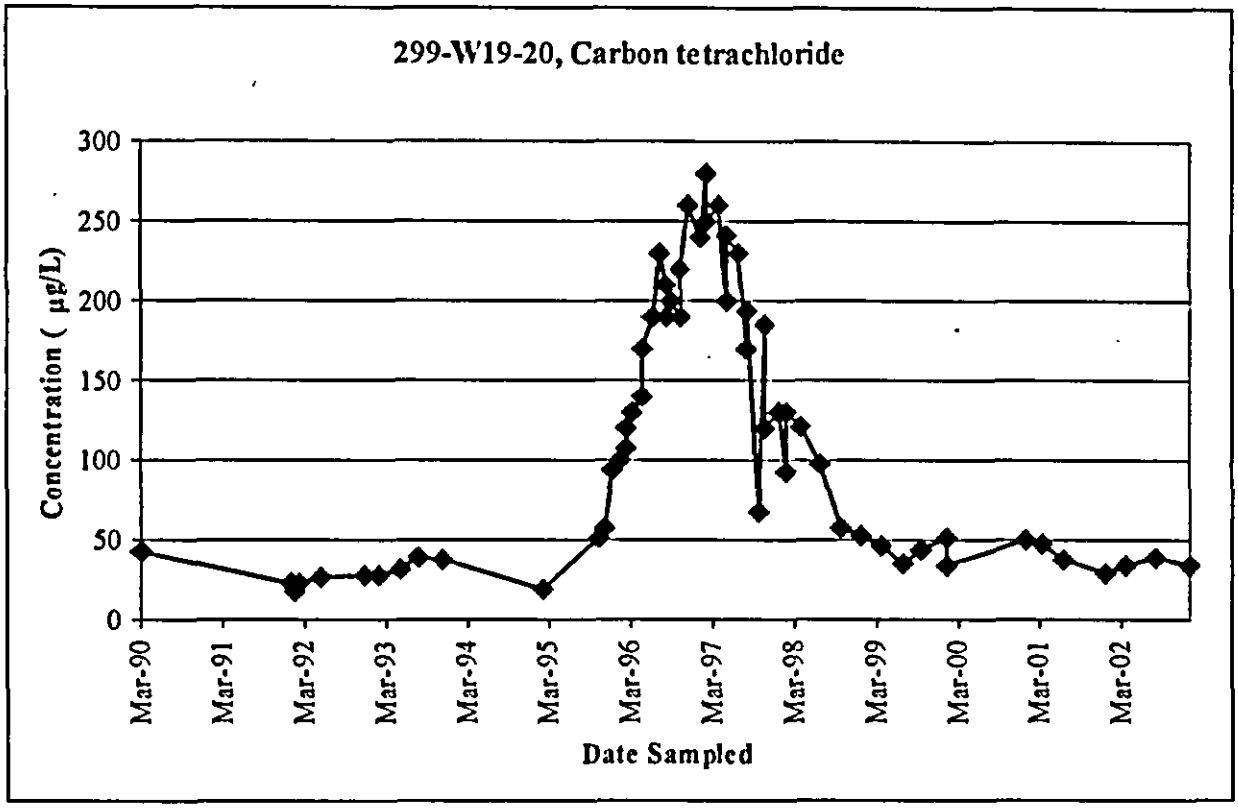

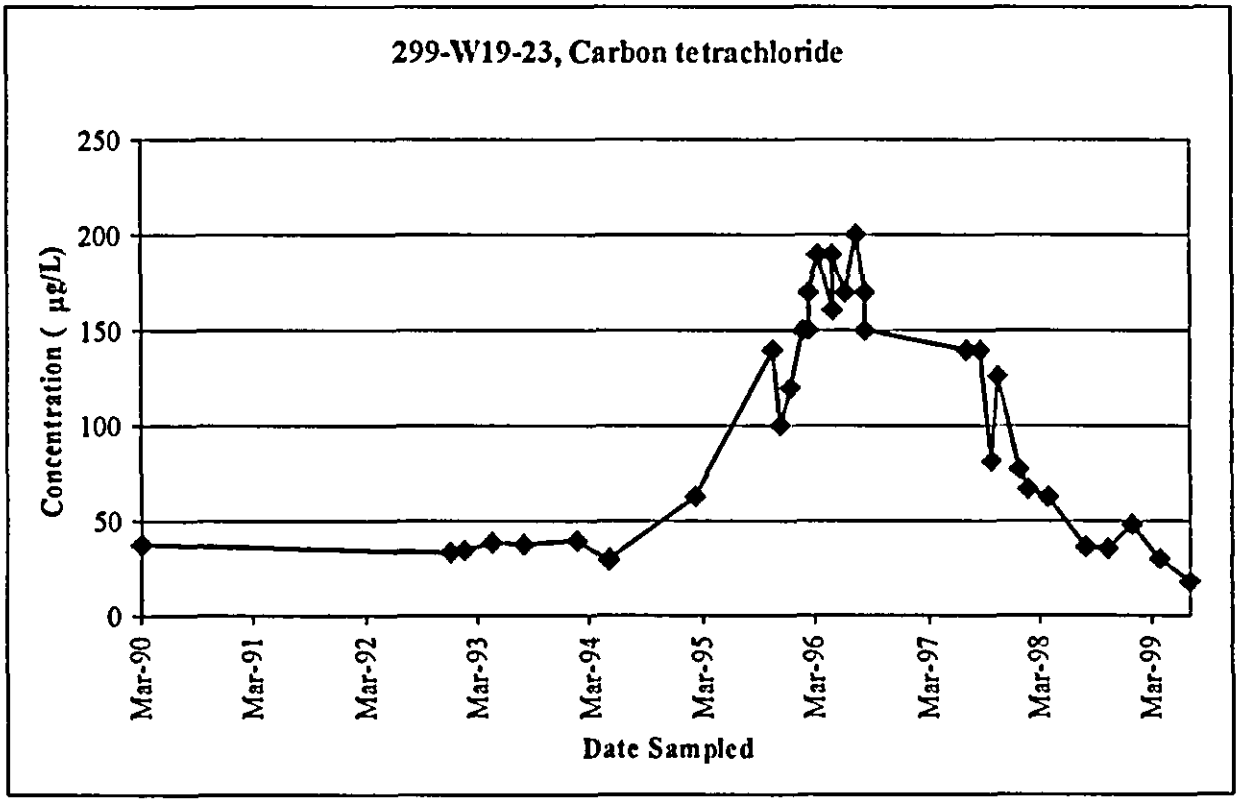

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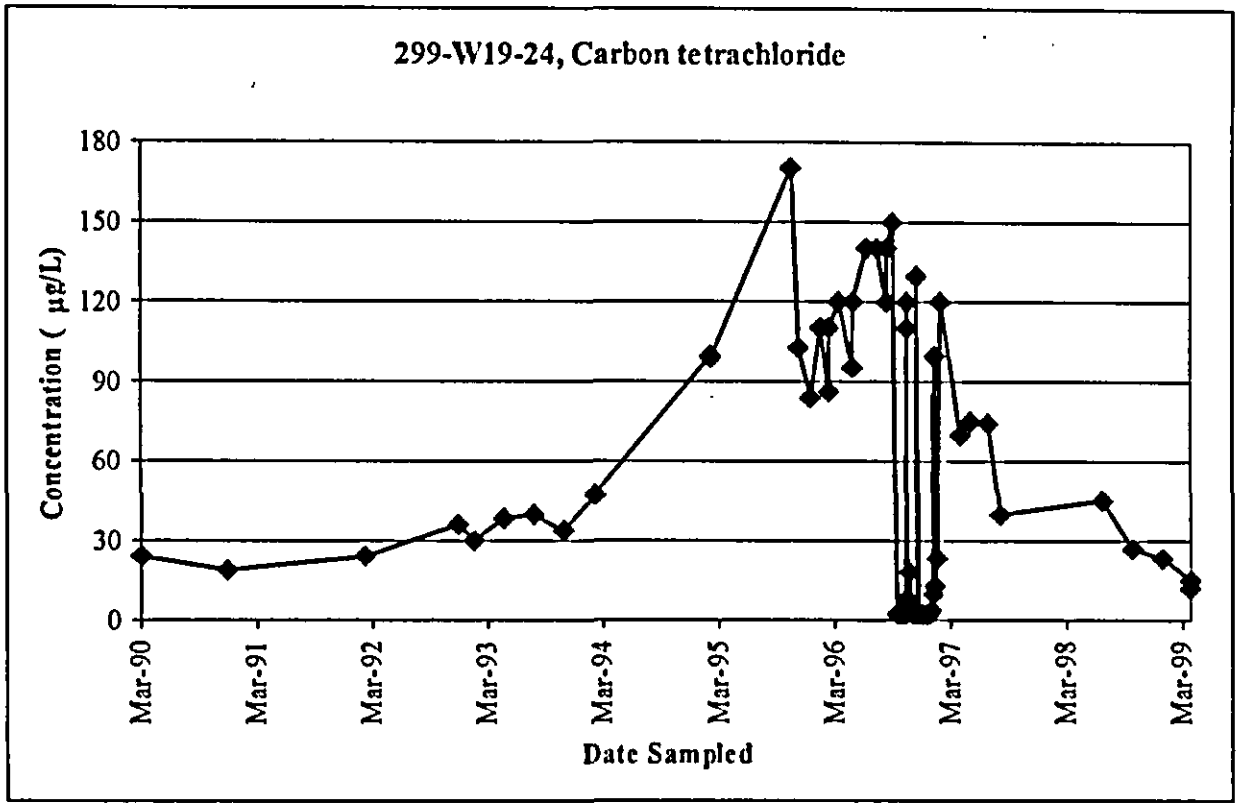

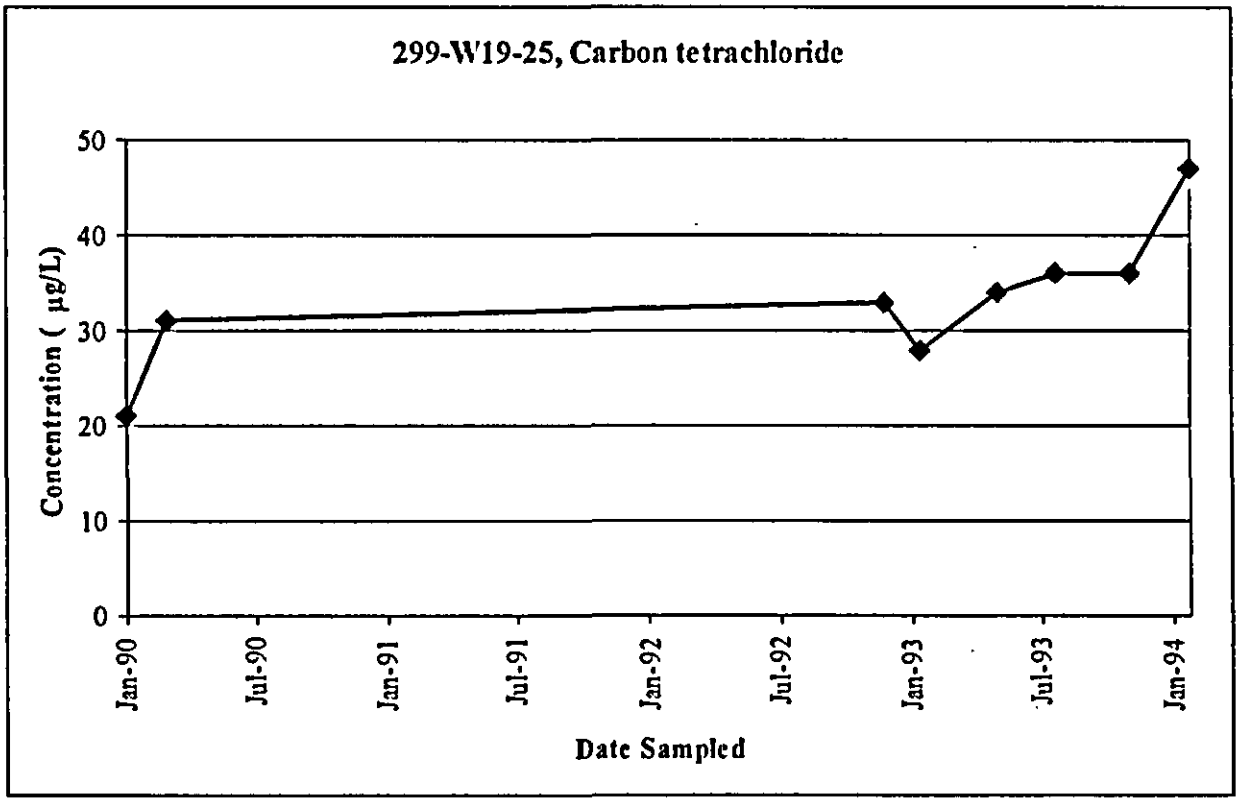

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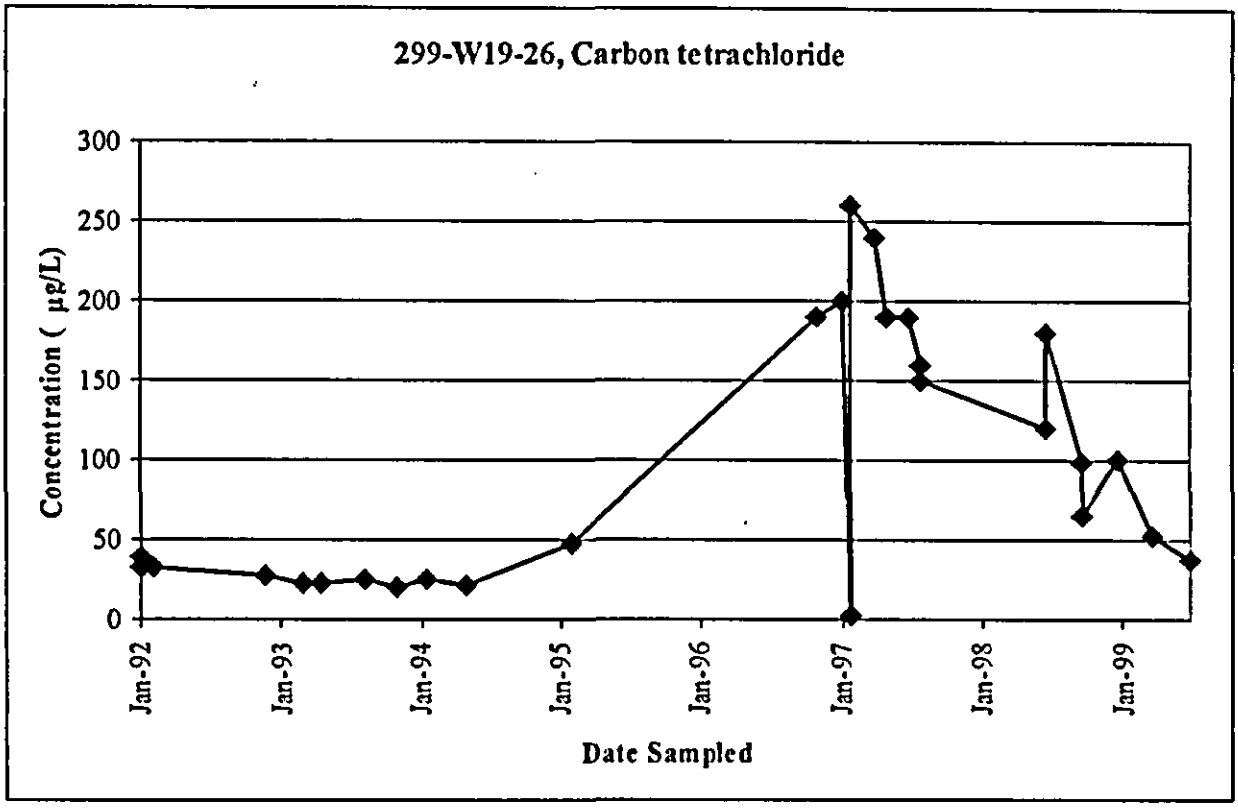

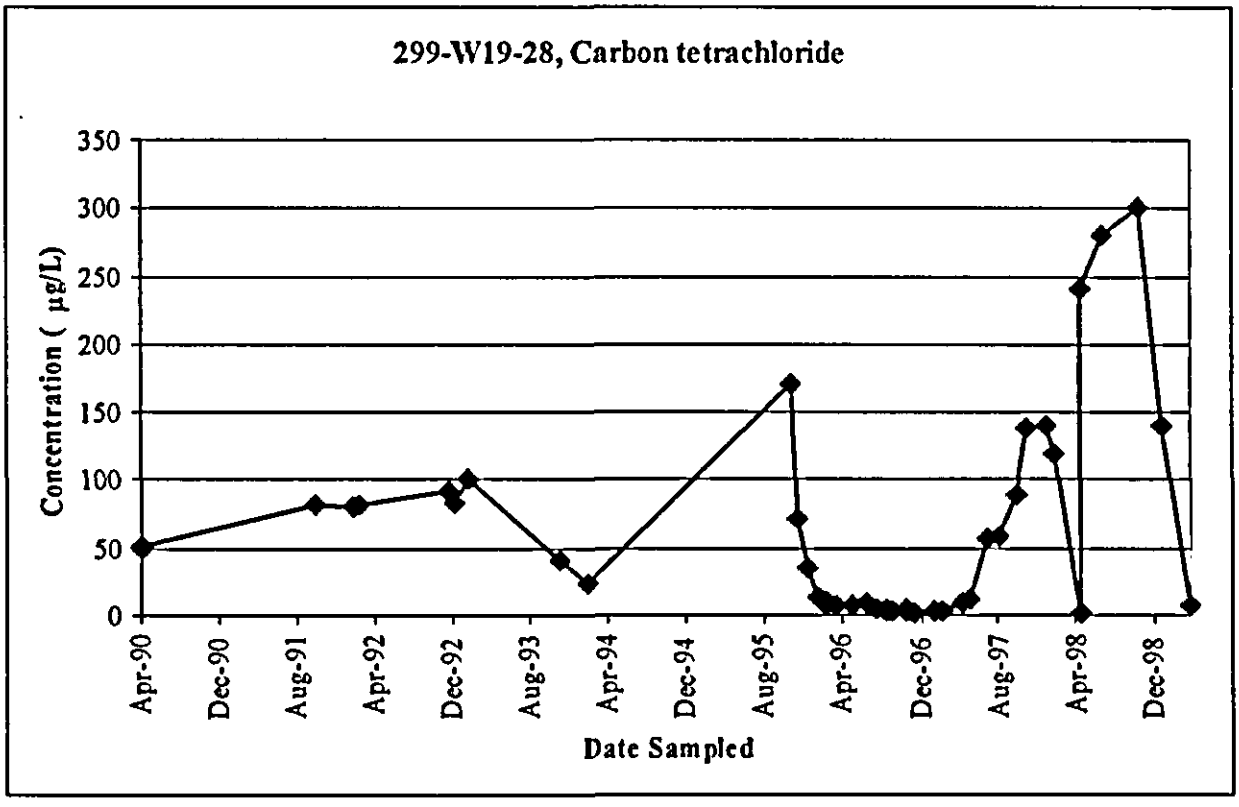

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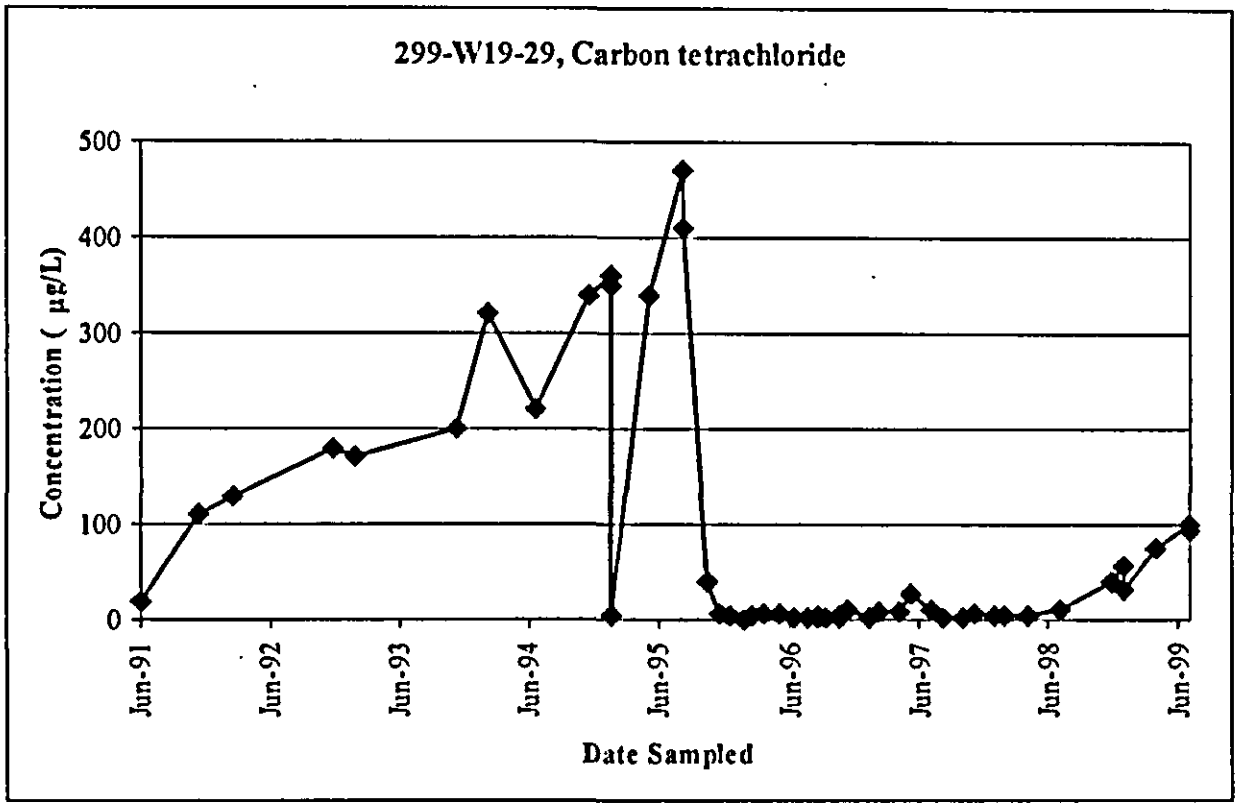

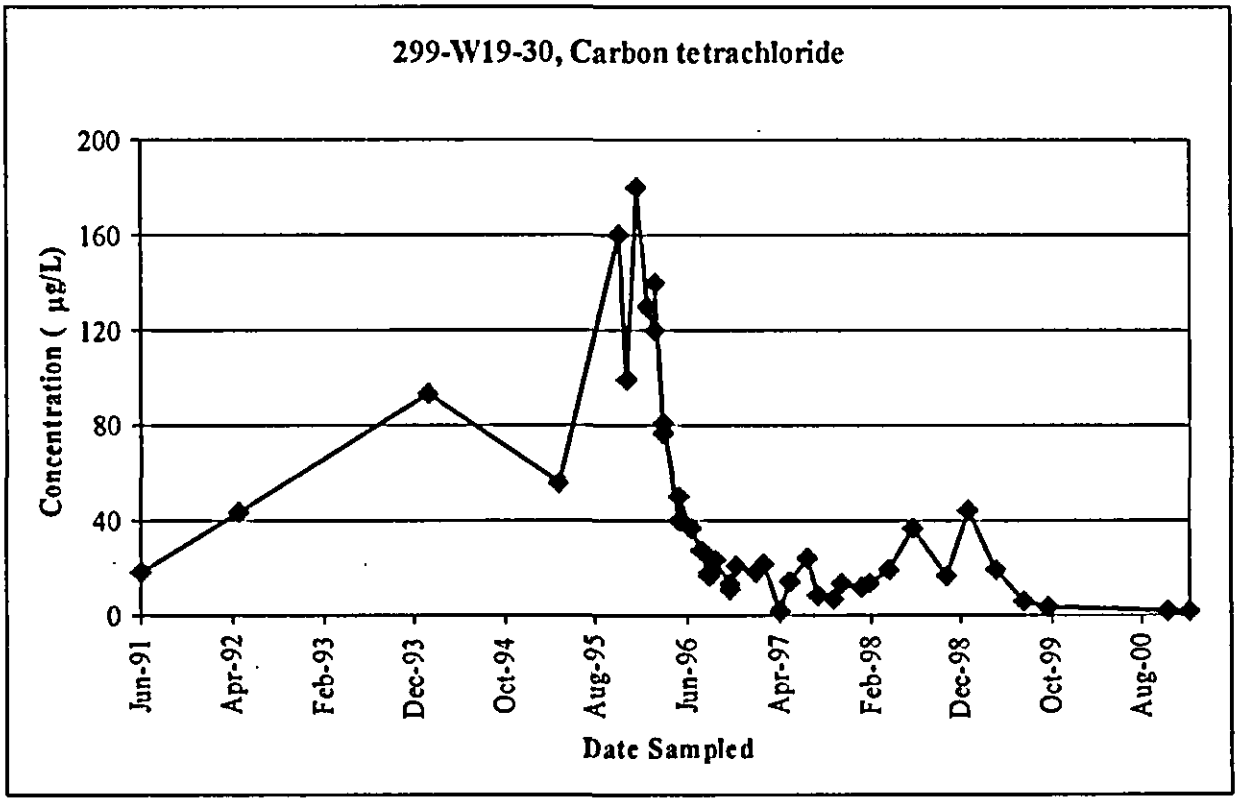

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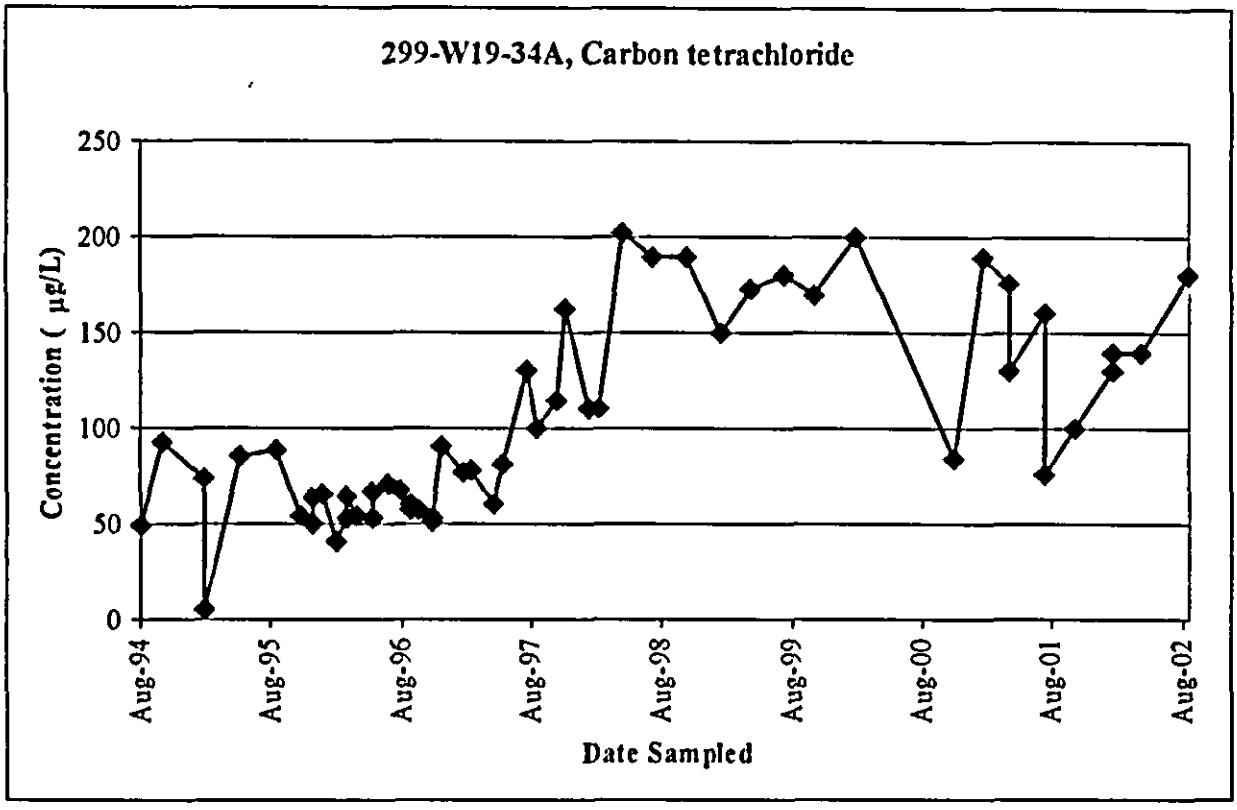

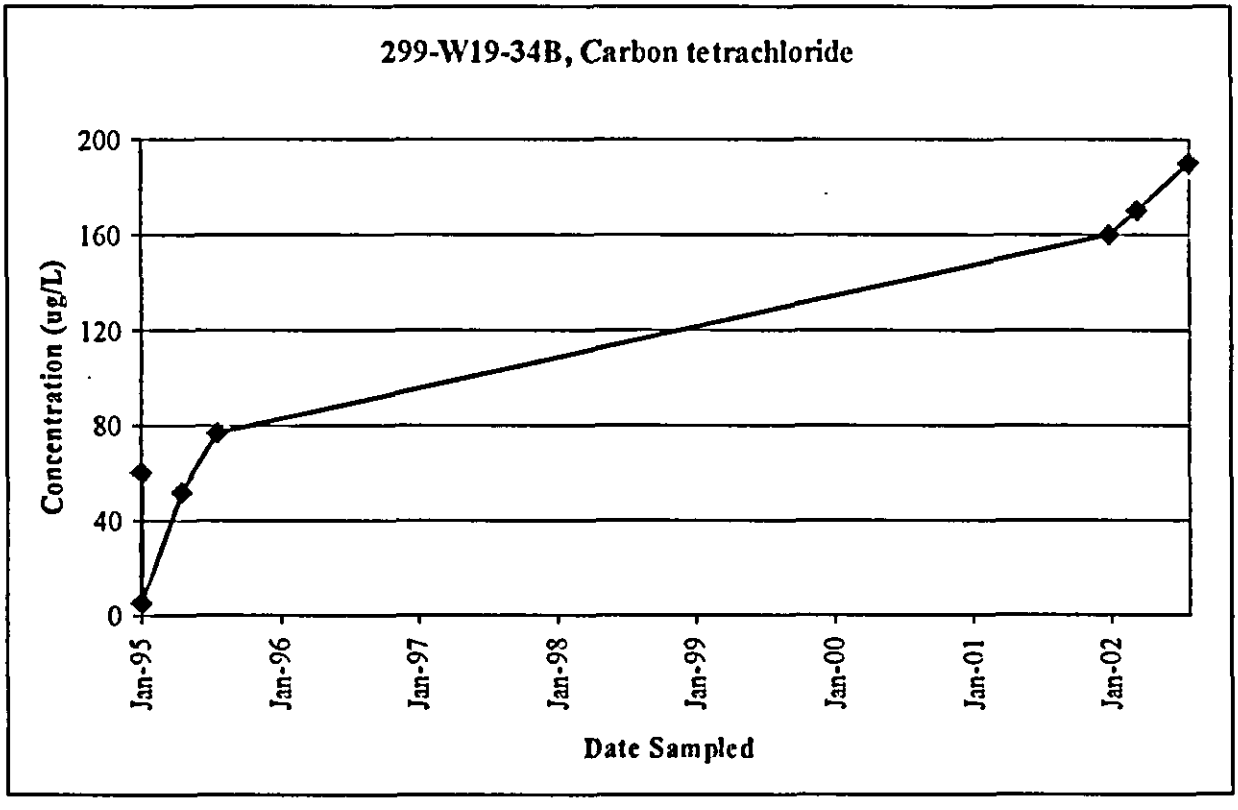

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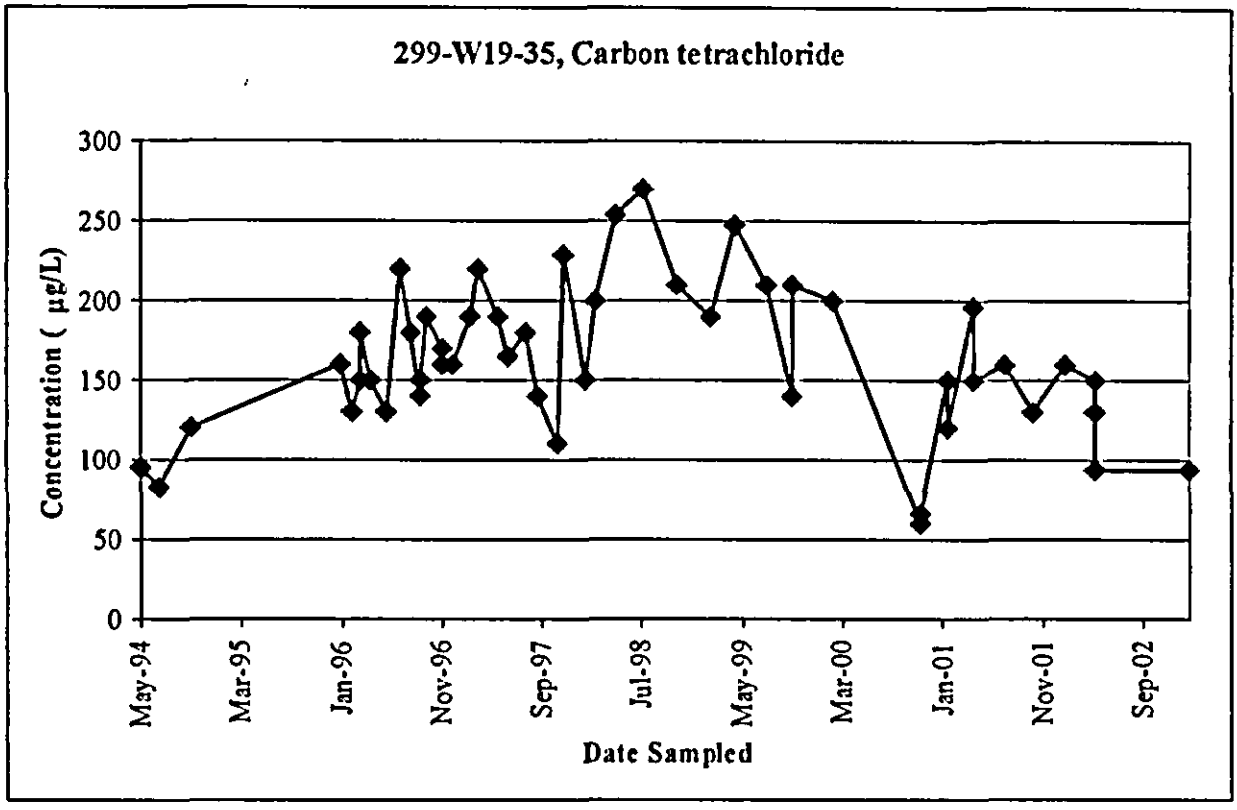

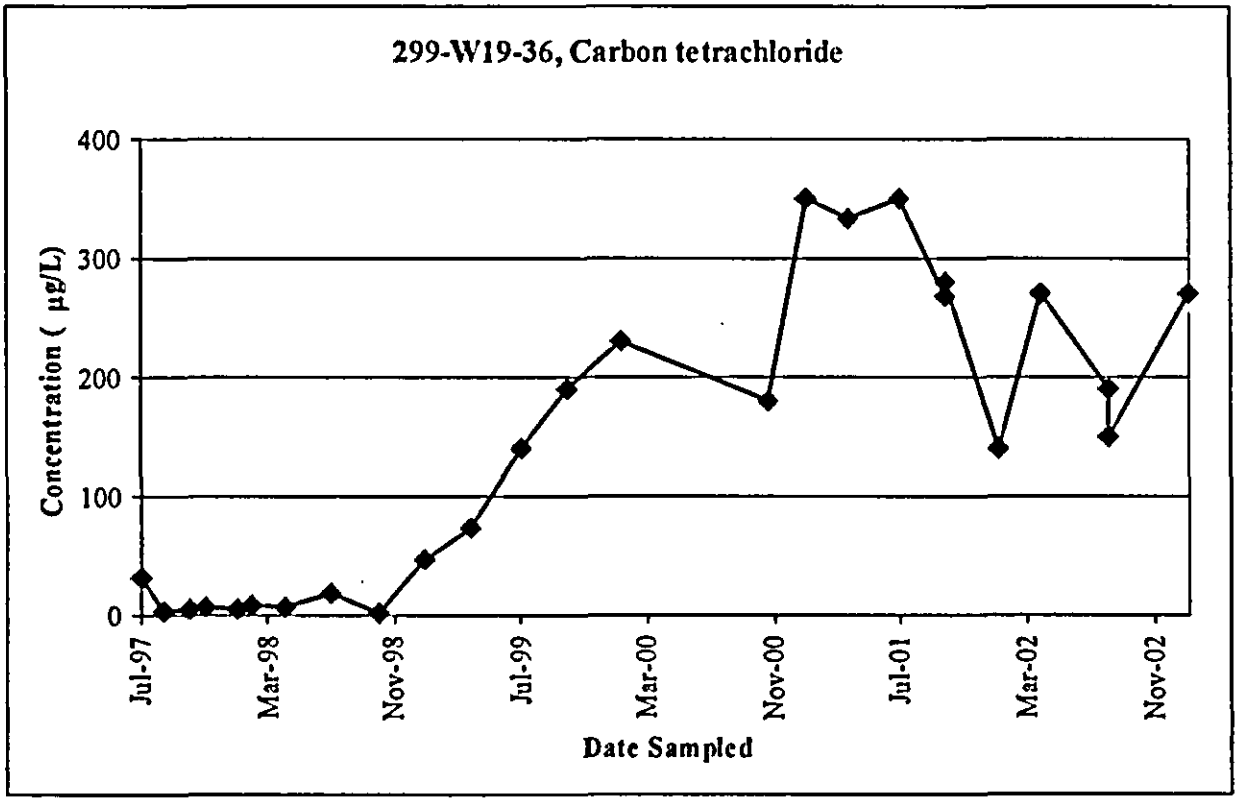

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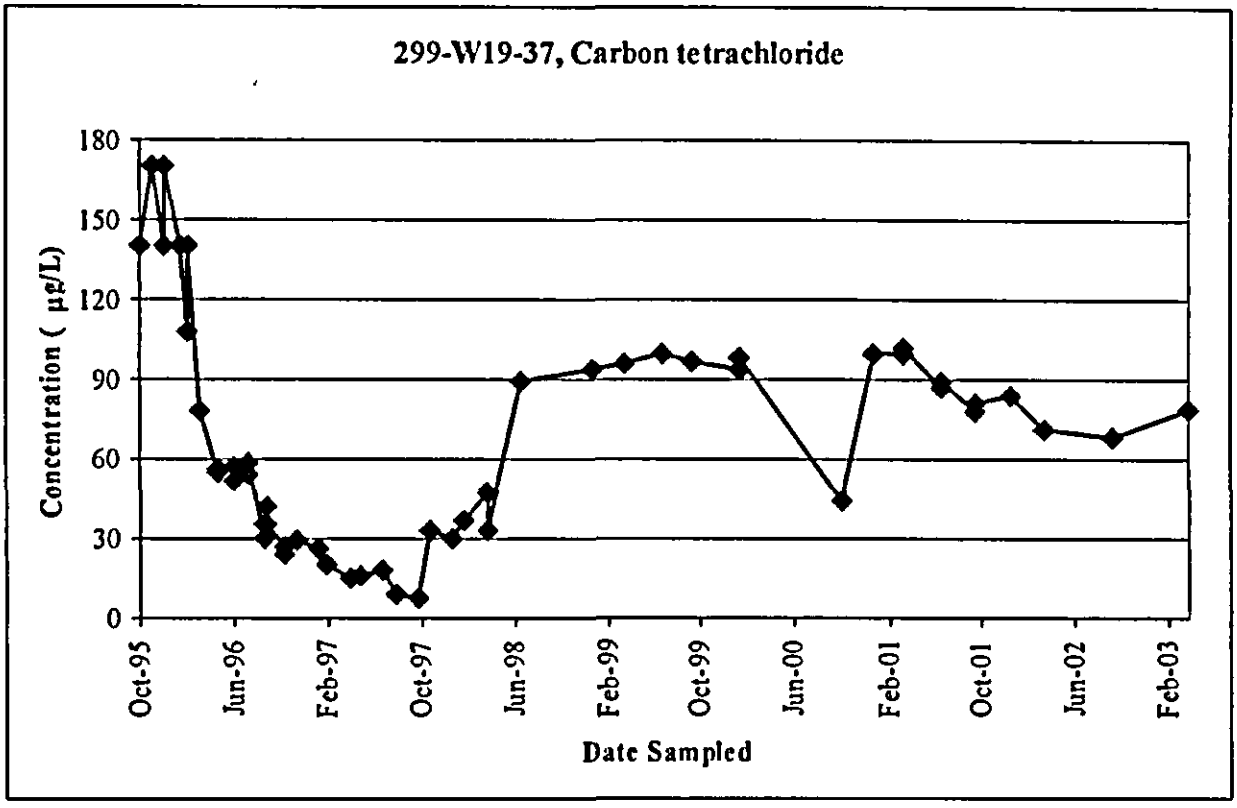

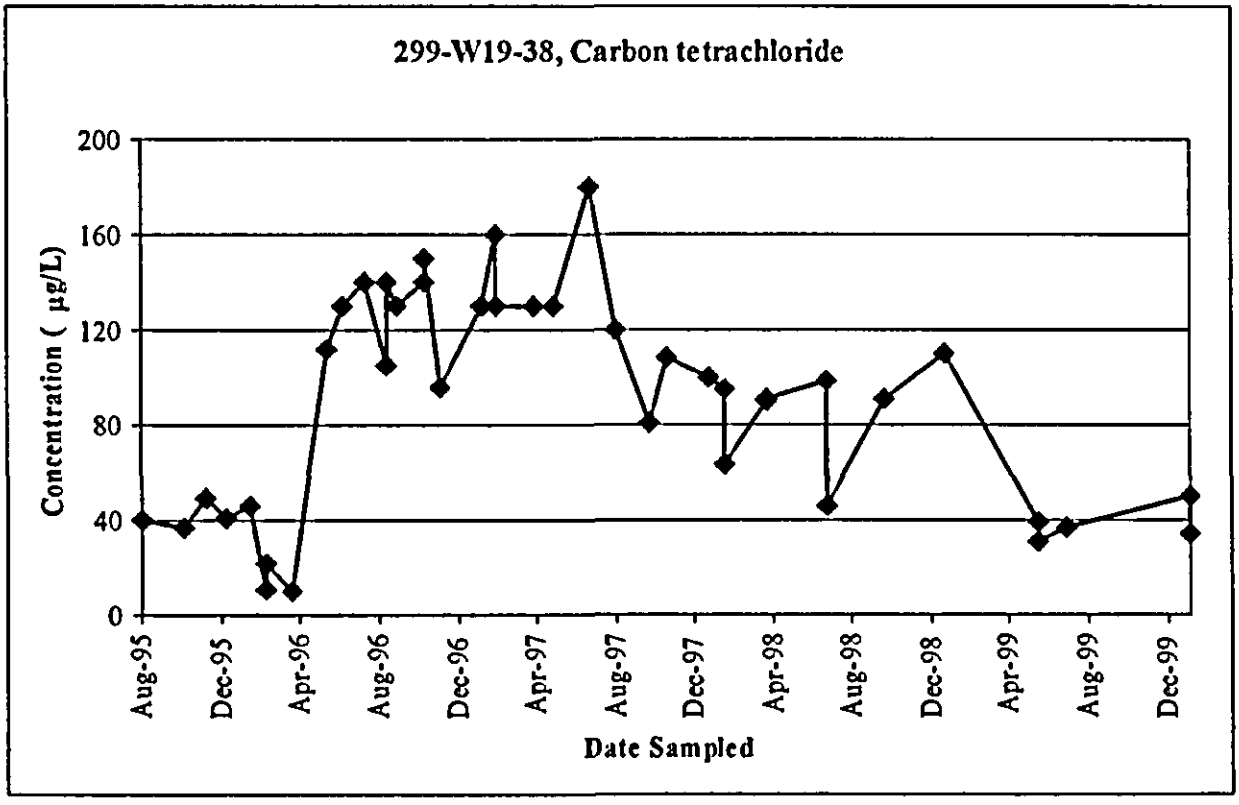

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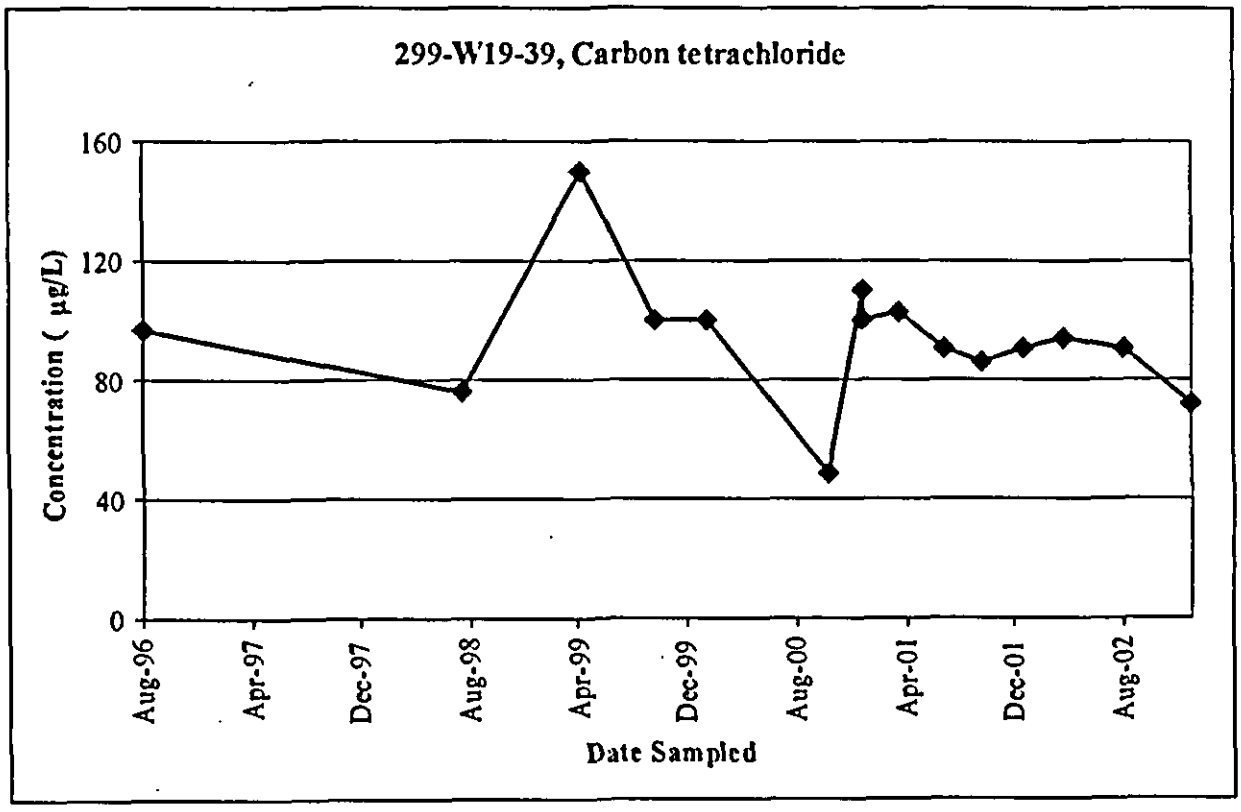

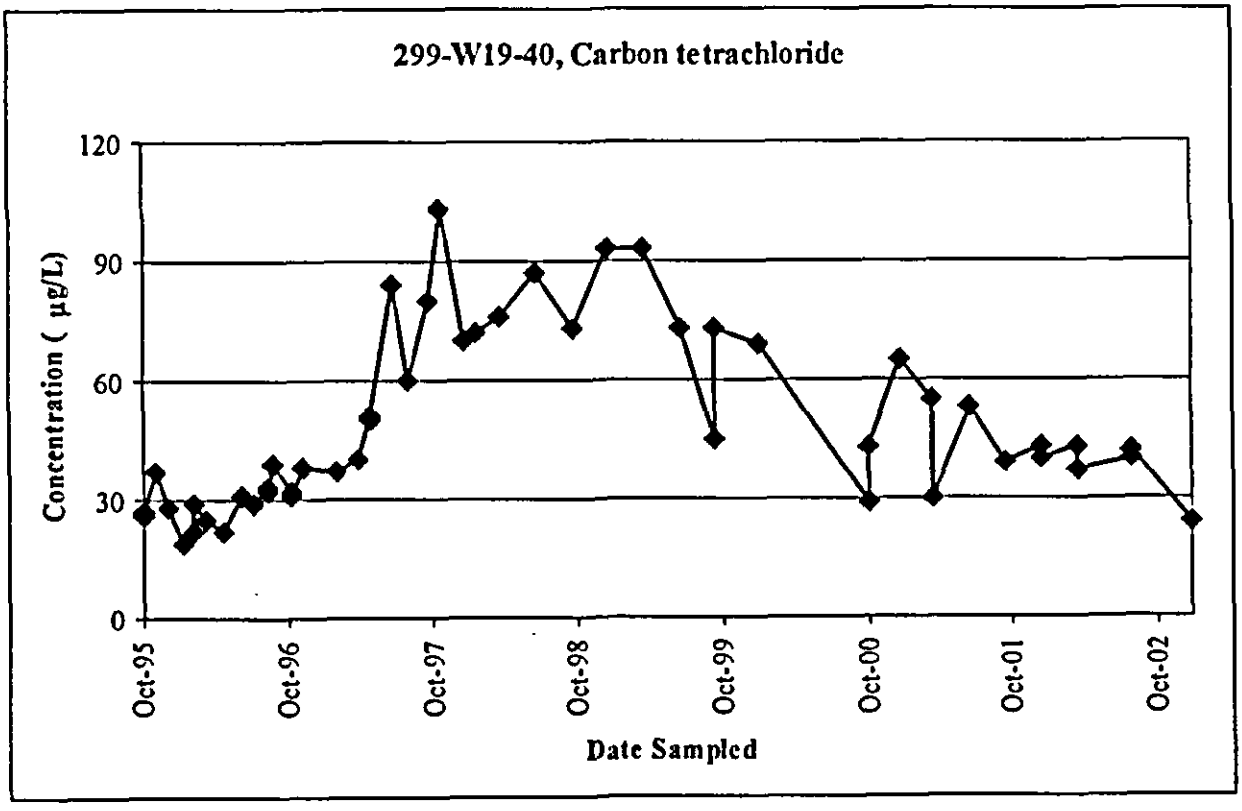

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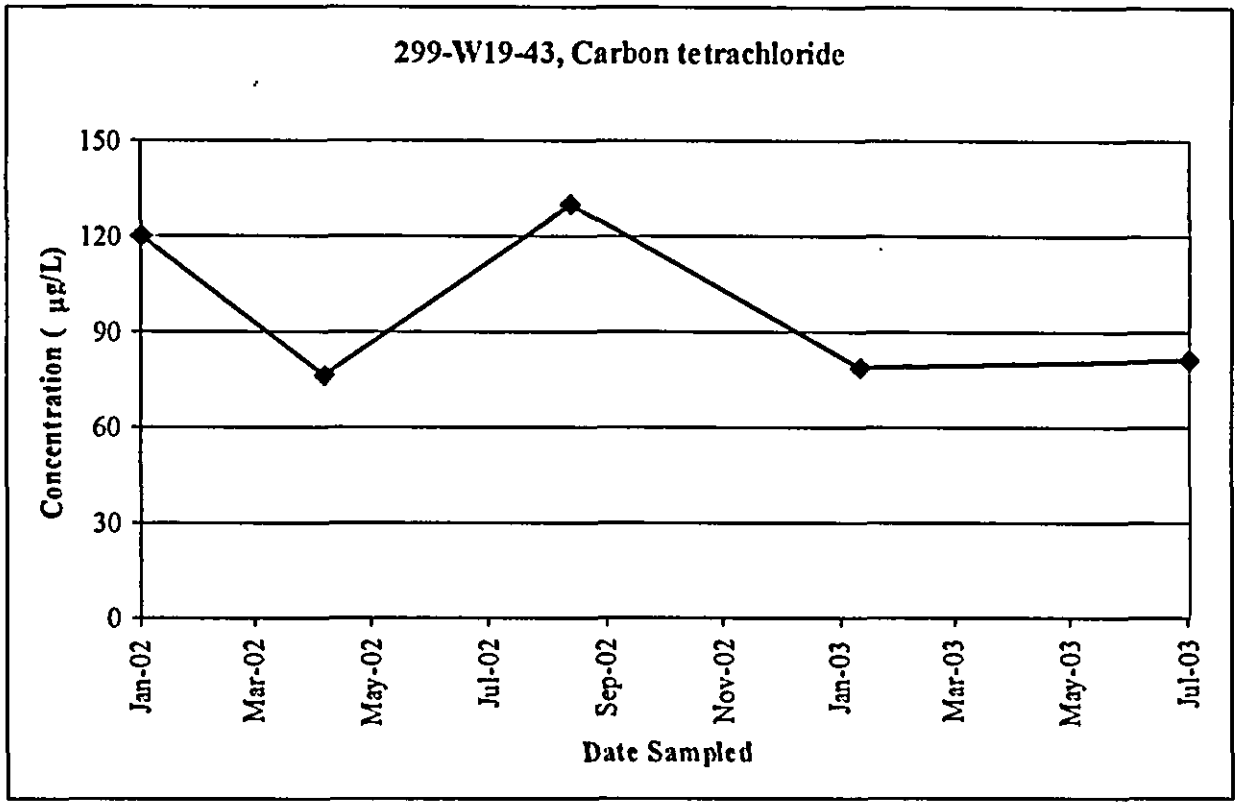

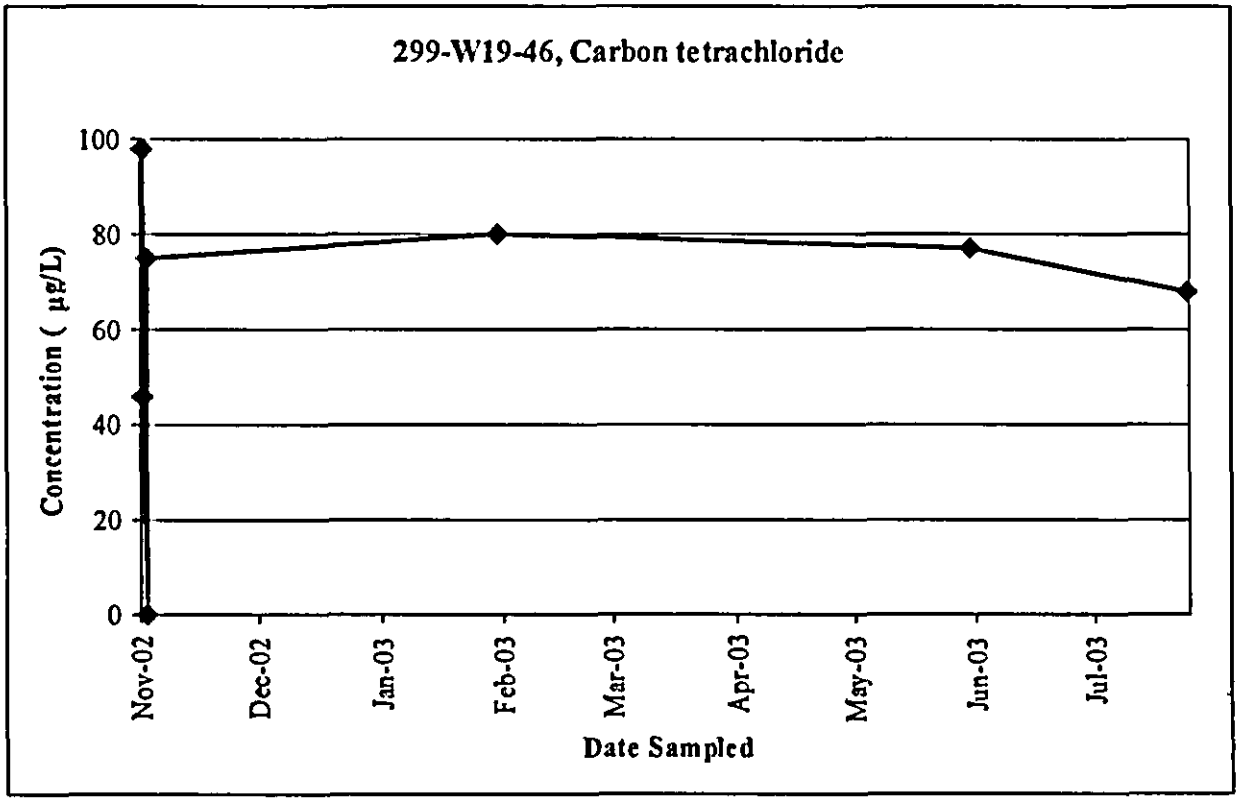

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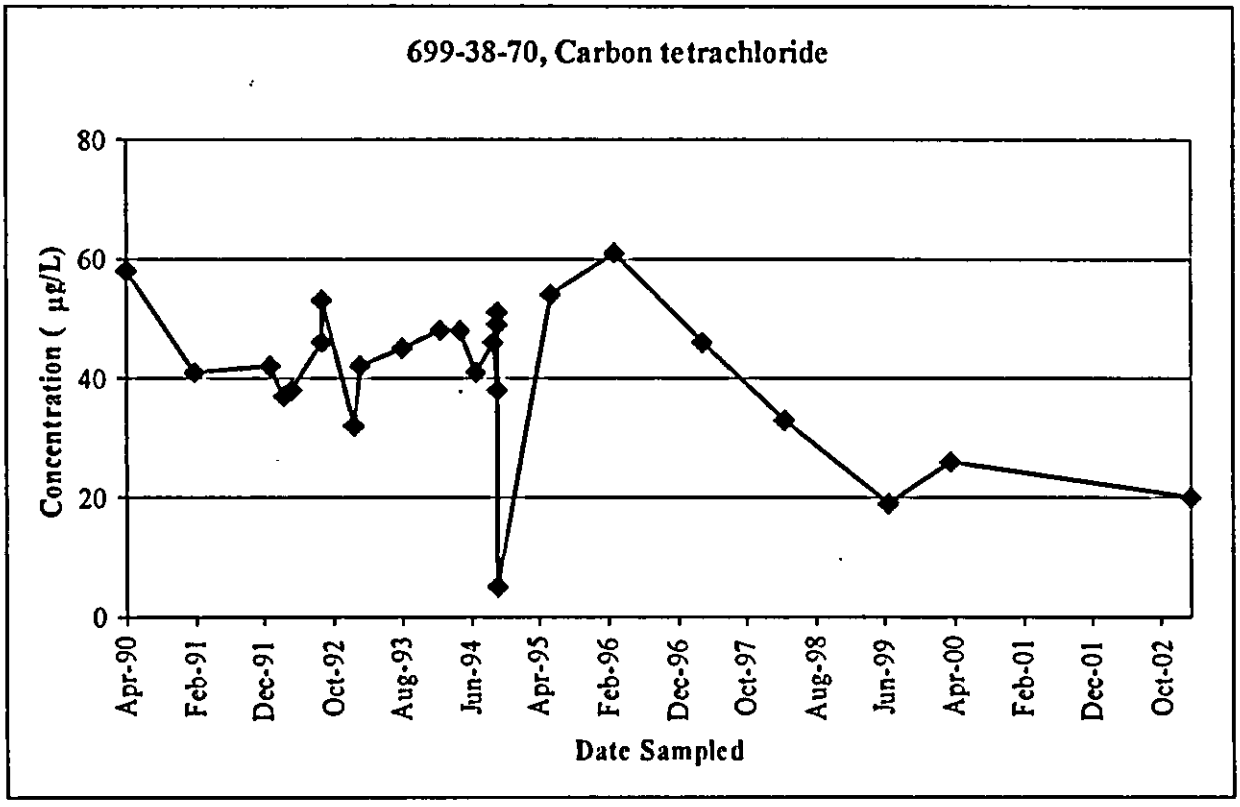
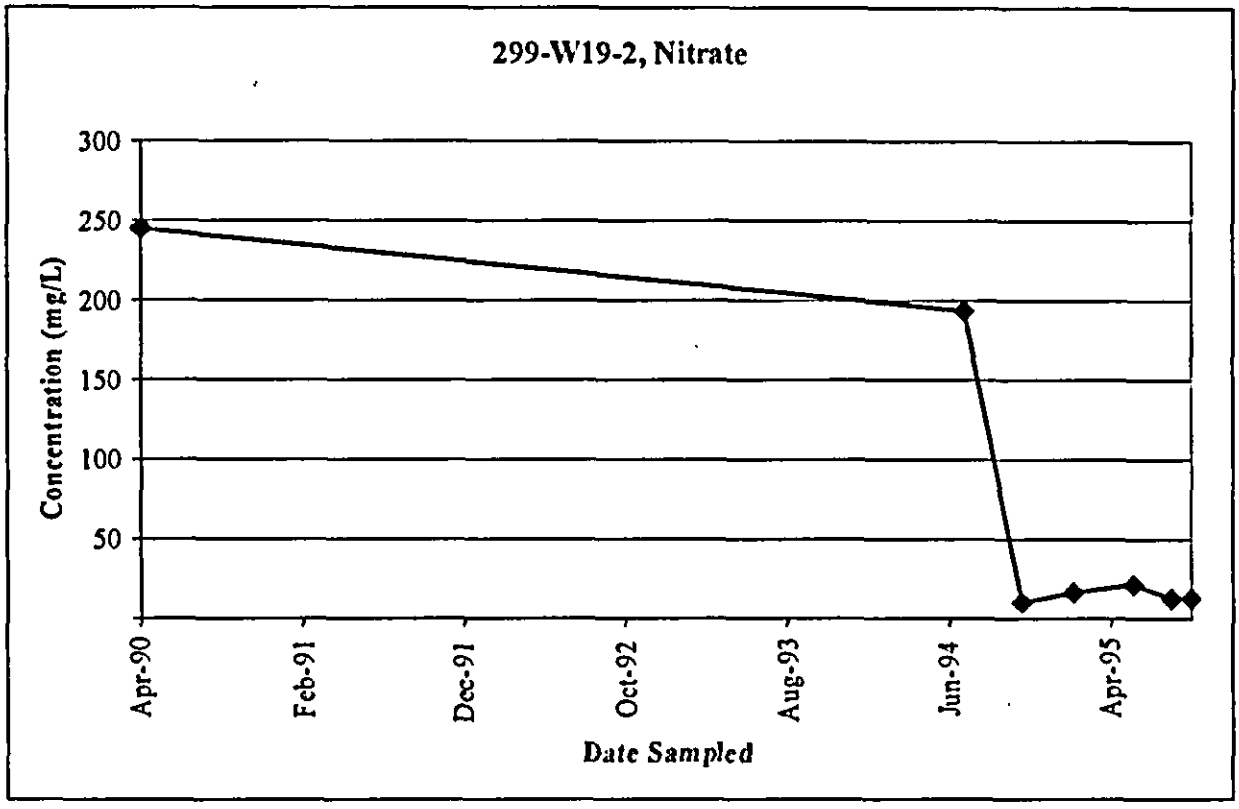
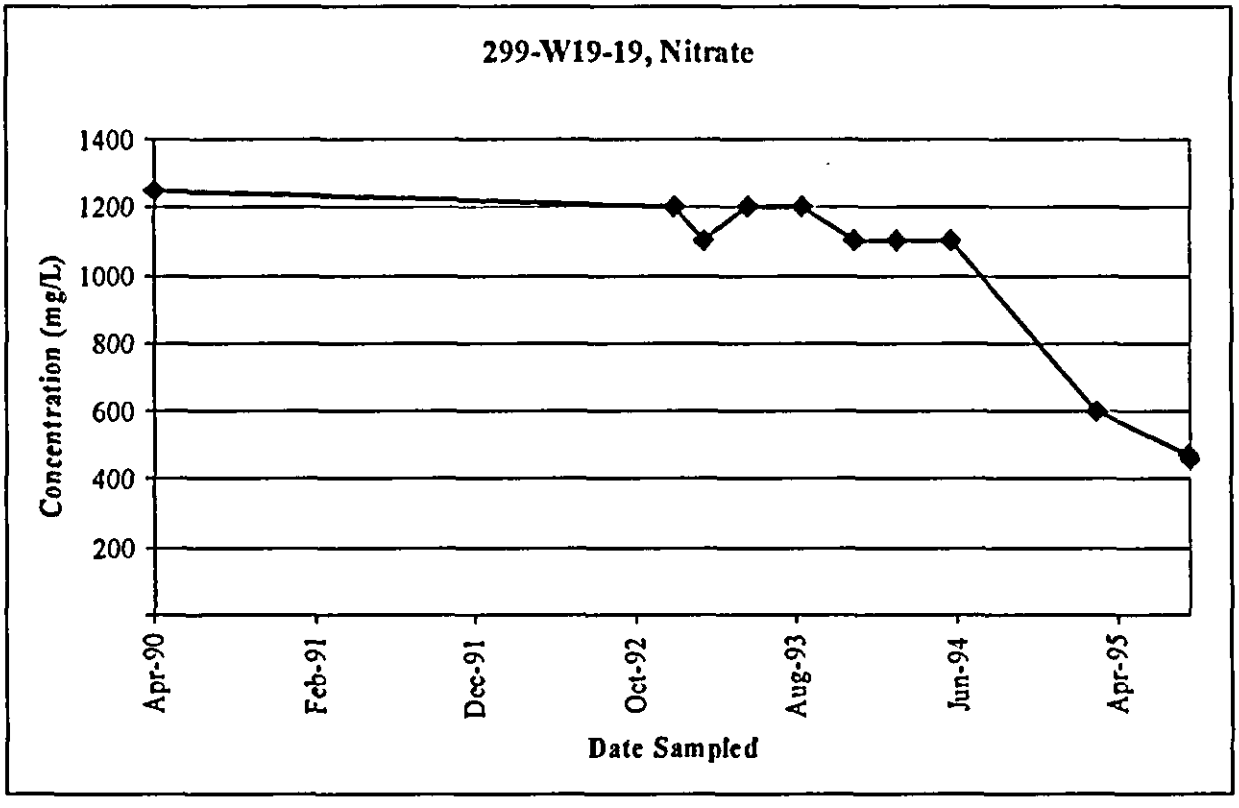


Figure D-4. 200-UP-1 Groundwater Operable Unit, Nitrate Concentration Trends at Selected Monitoring Wells. (11 sheets)





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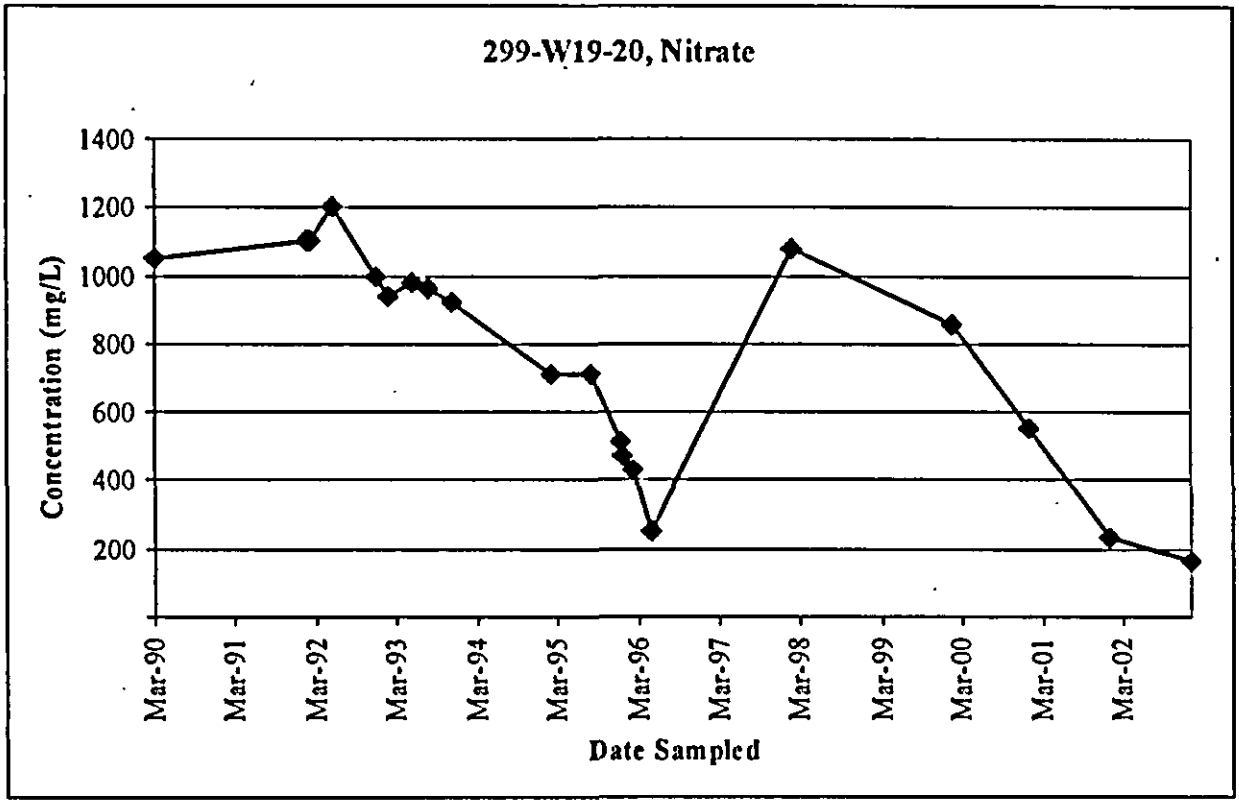

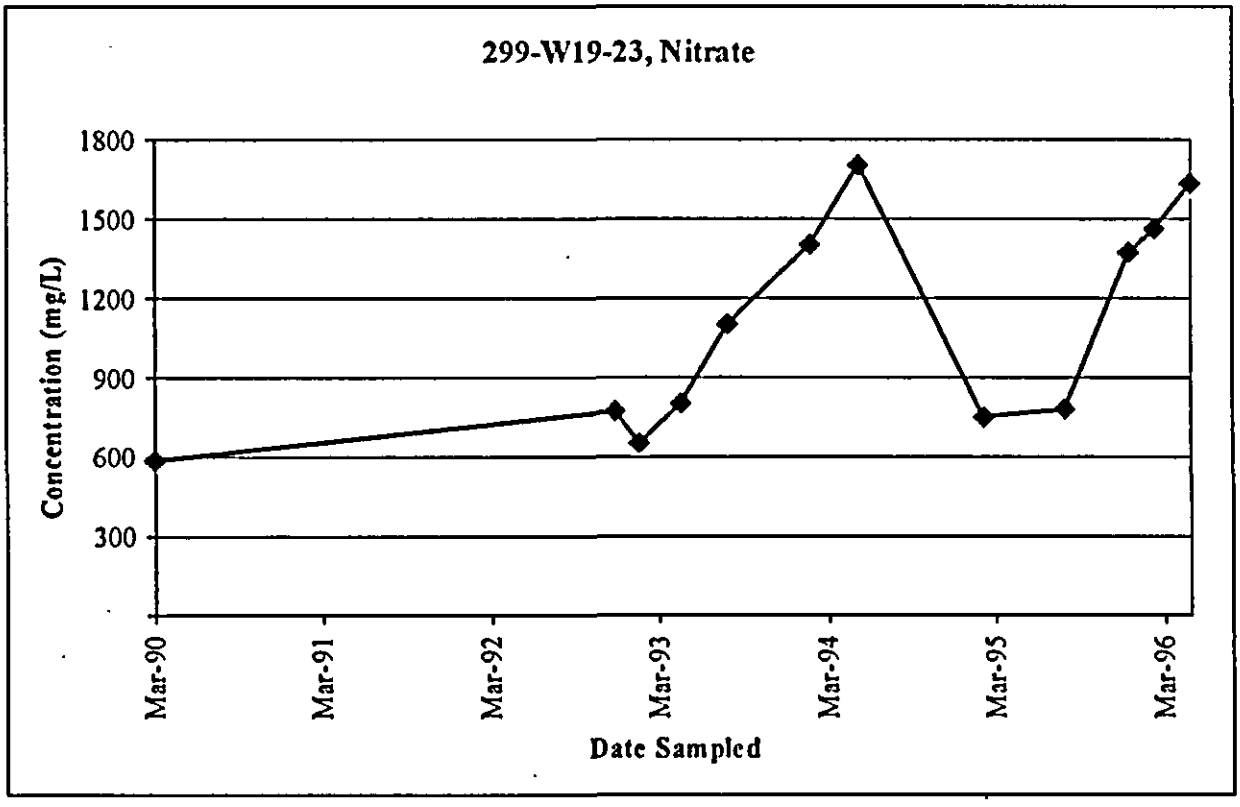

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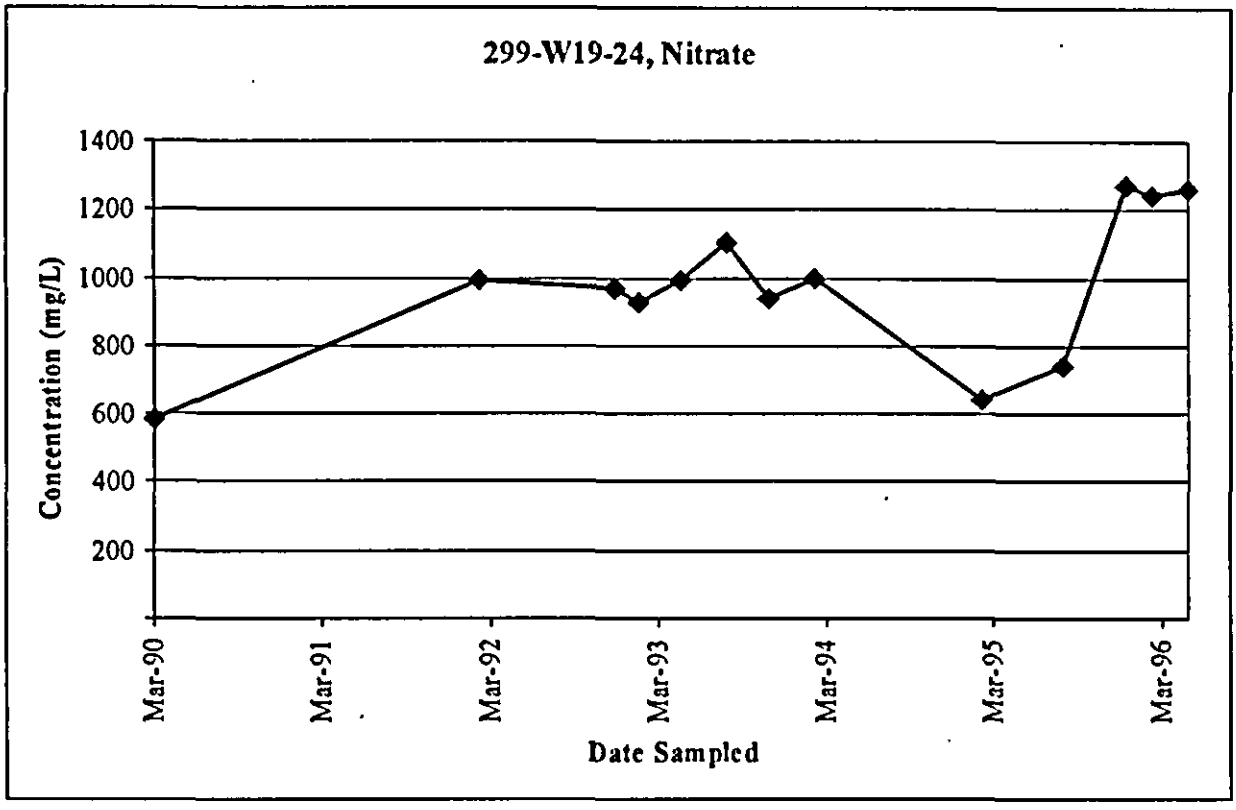

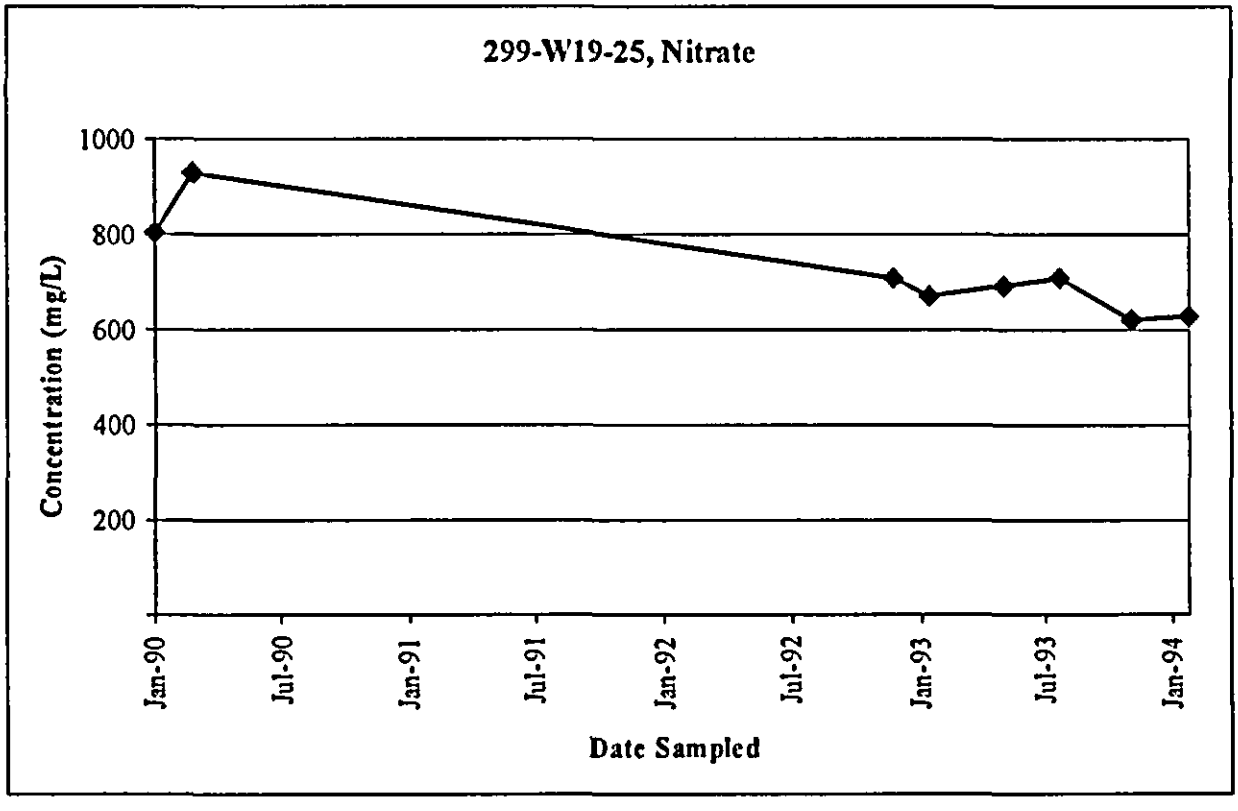

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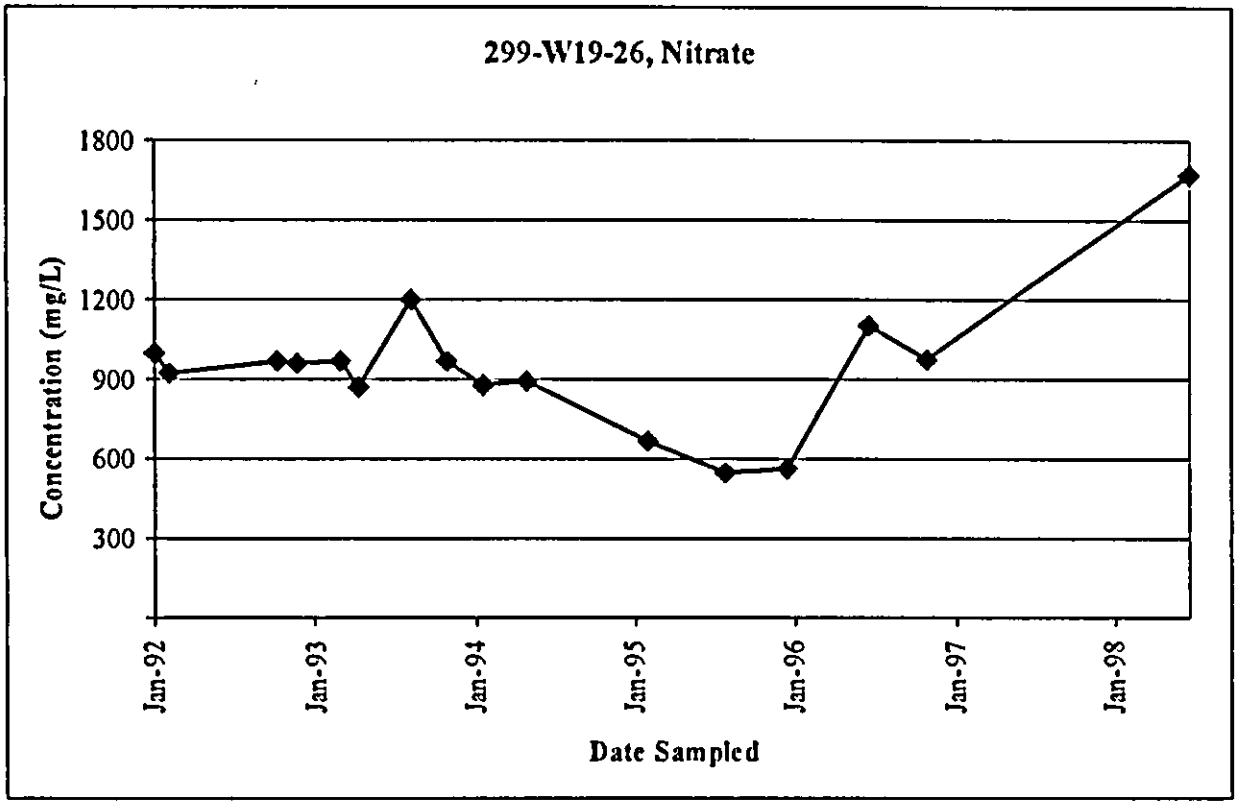

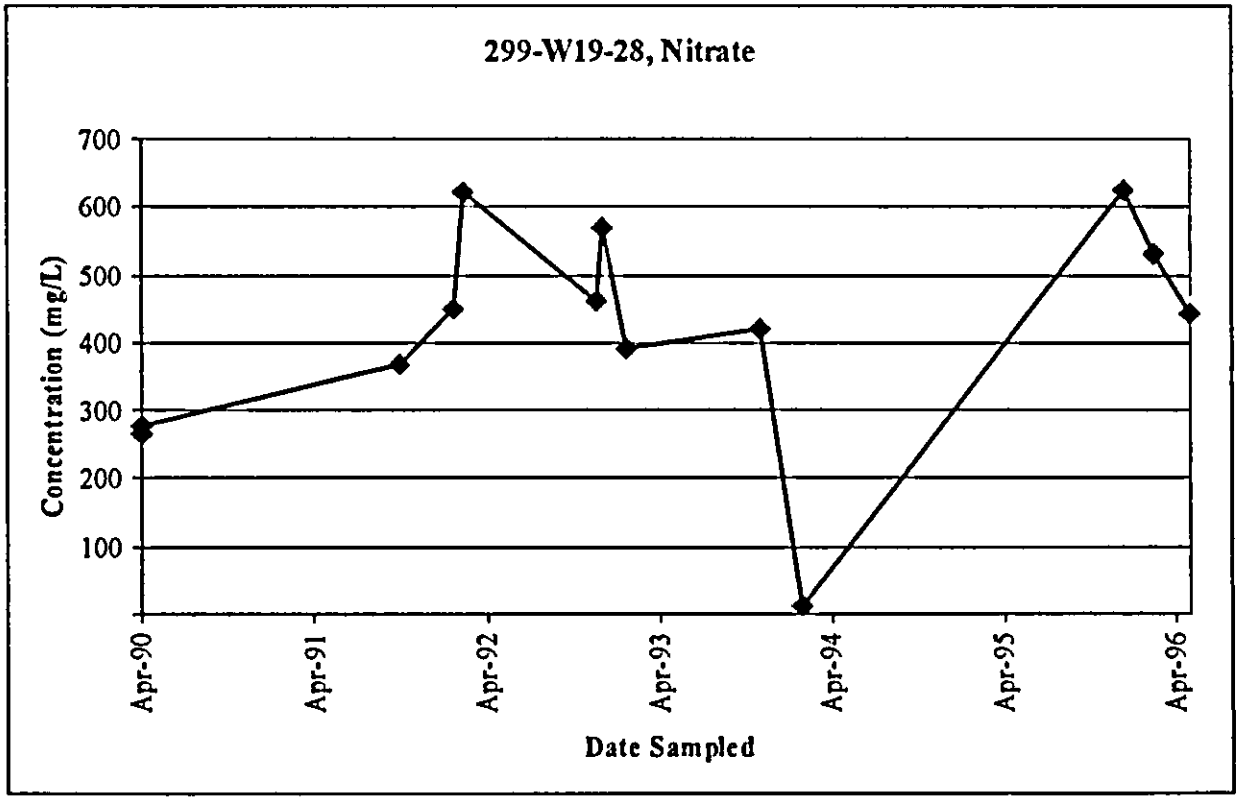

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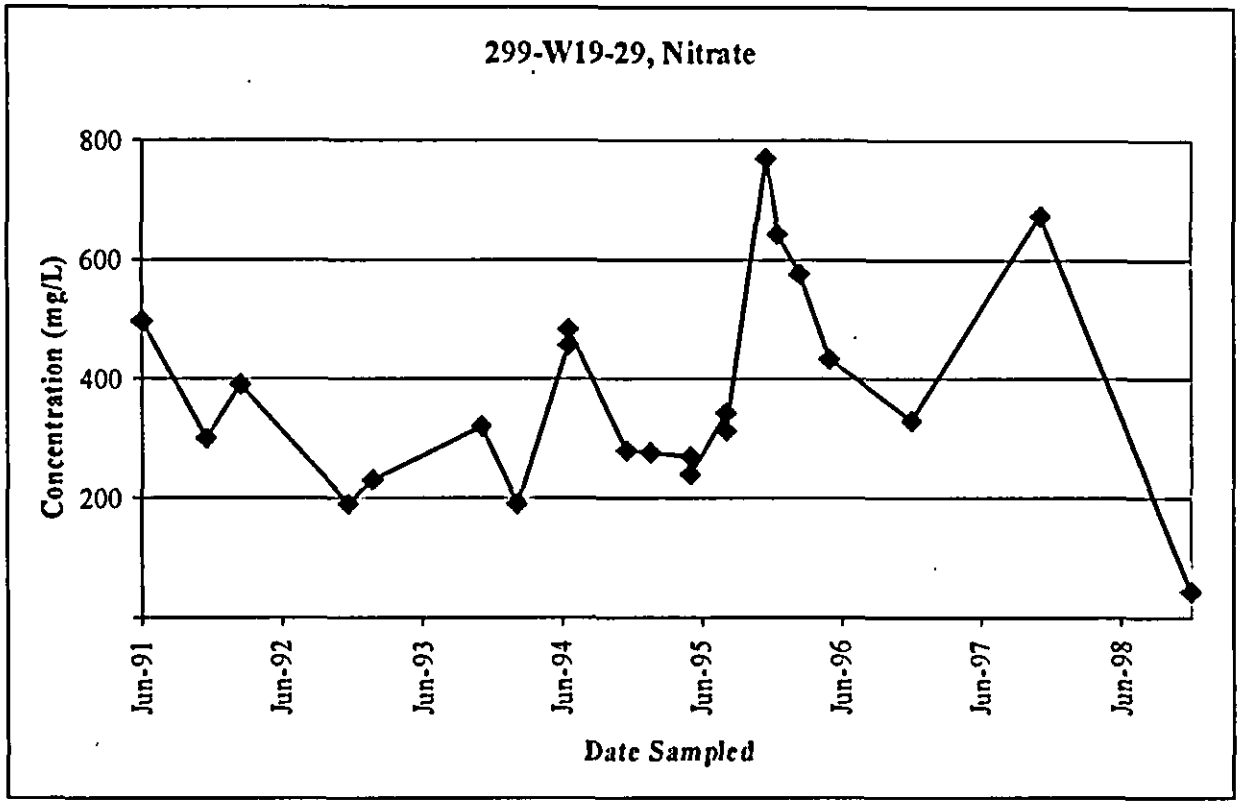

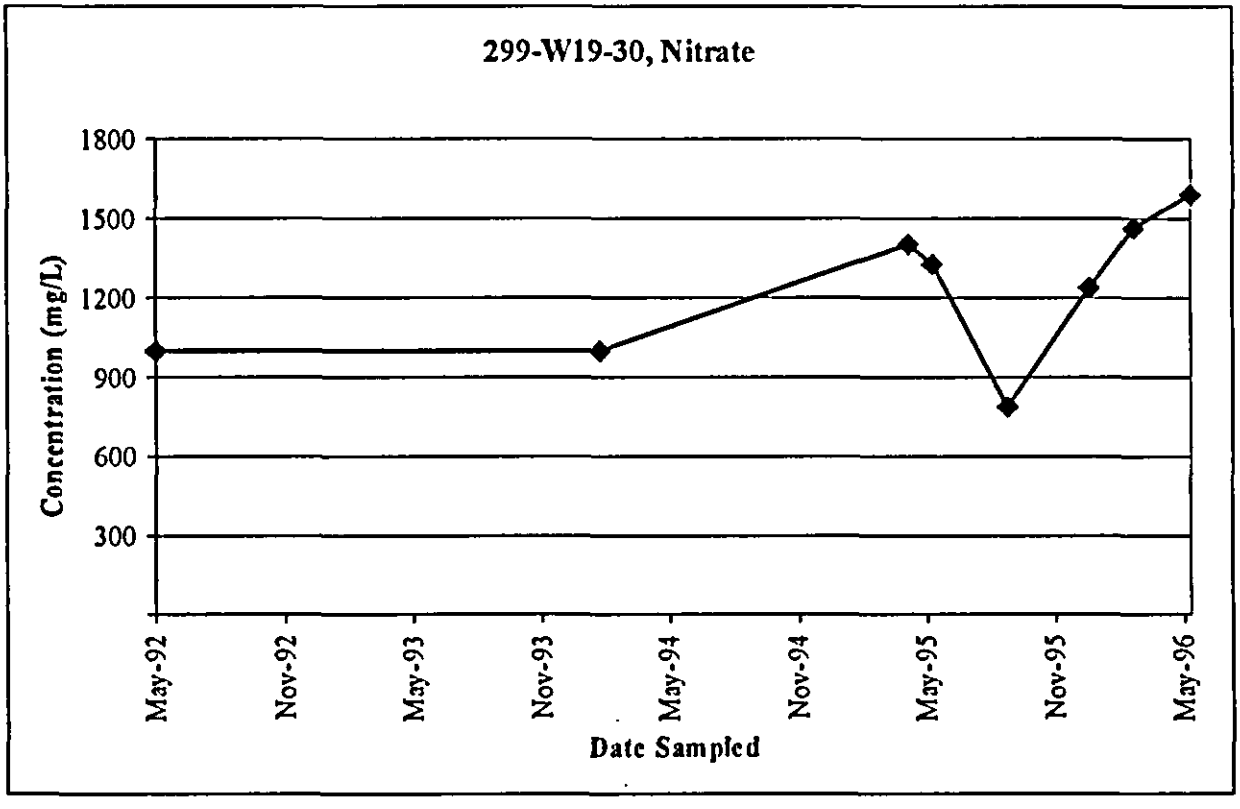

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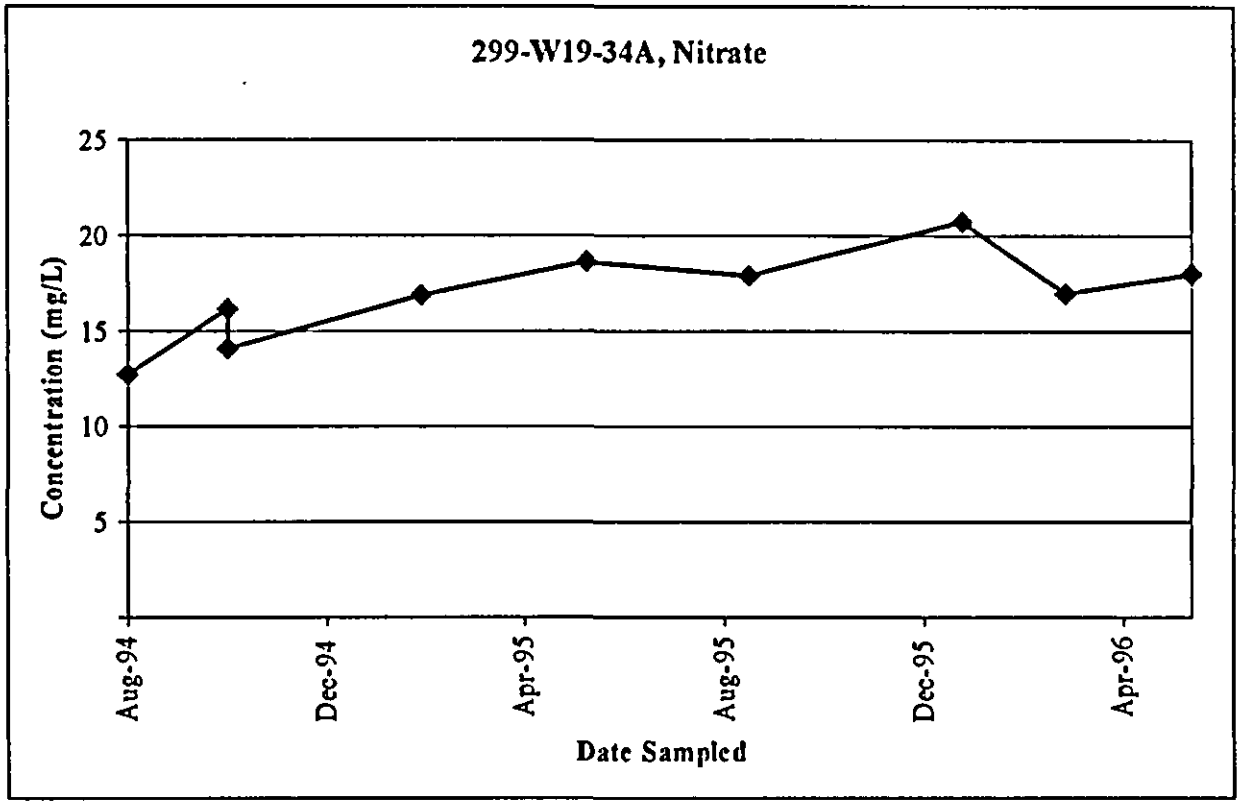

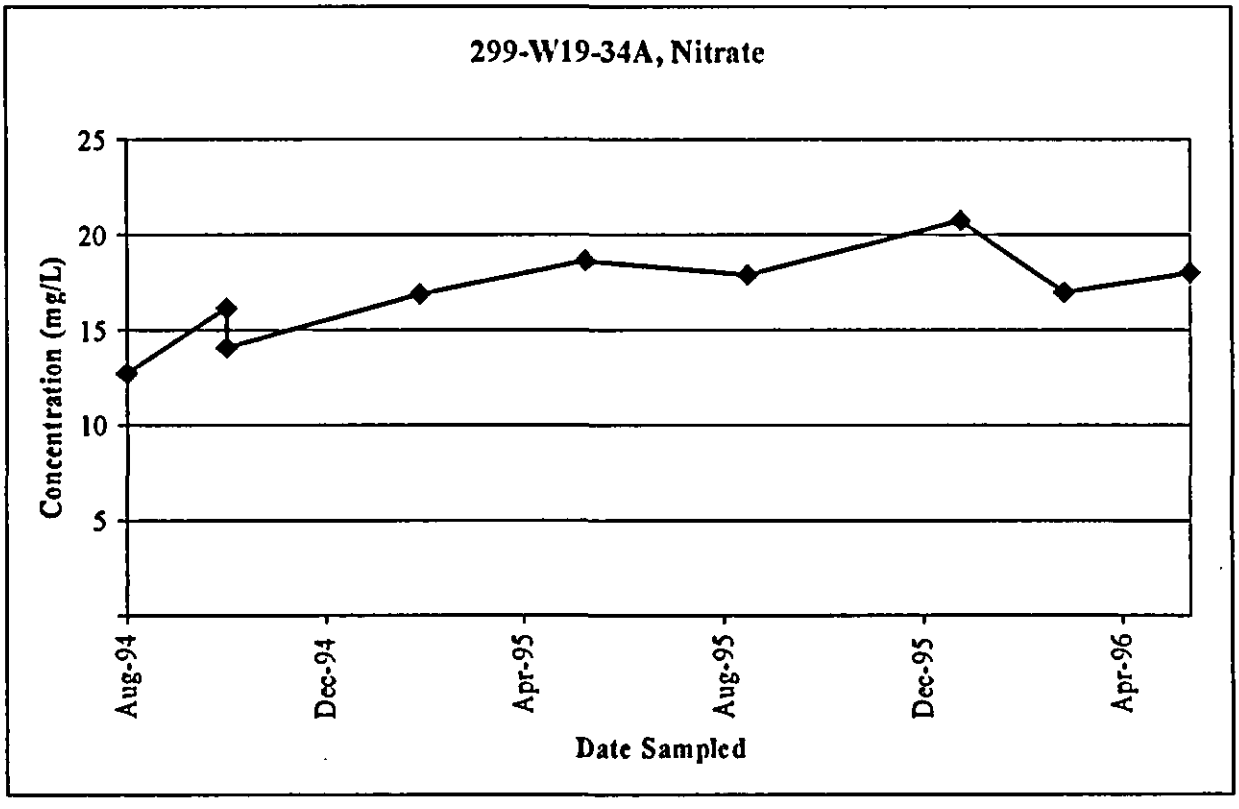

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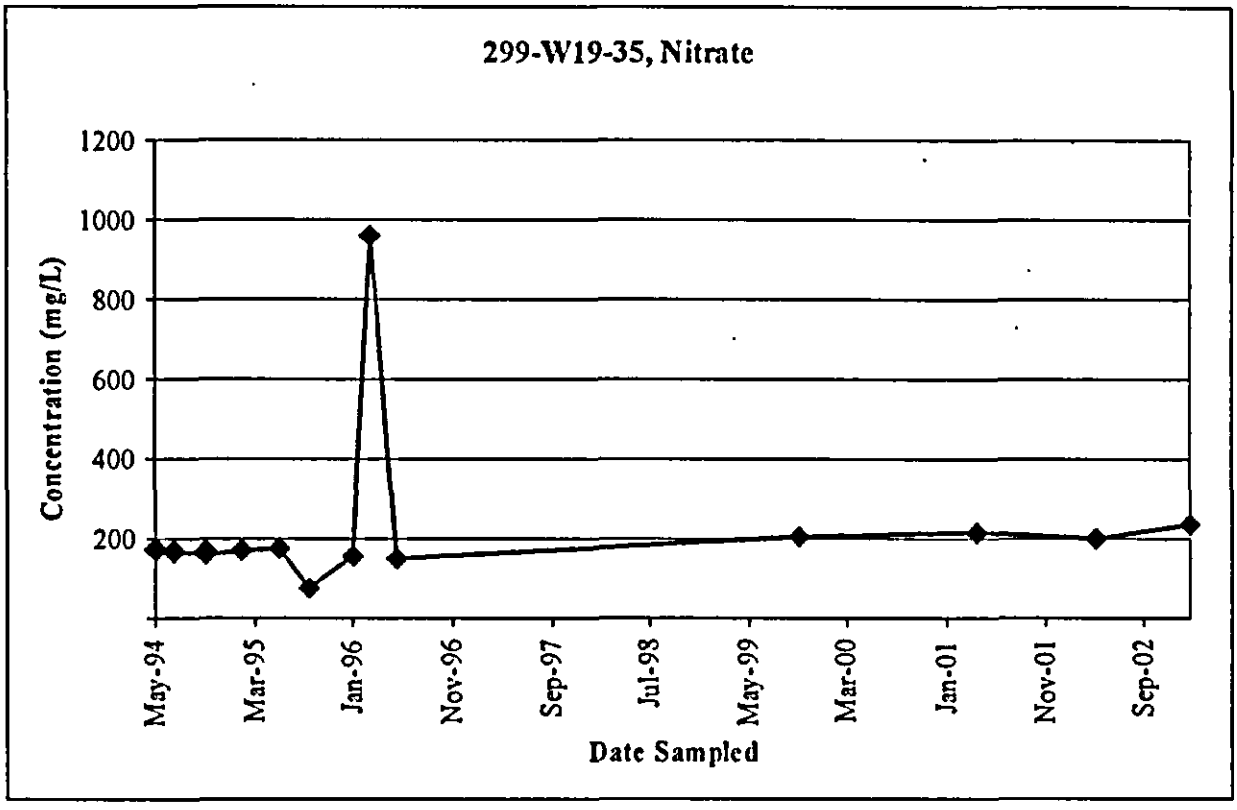

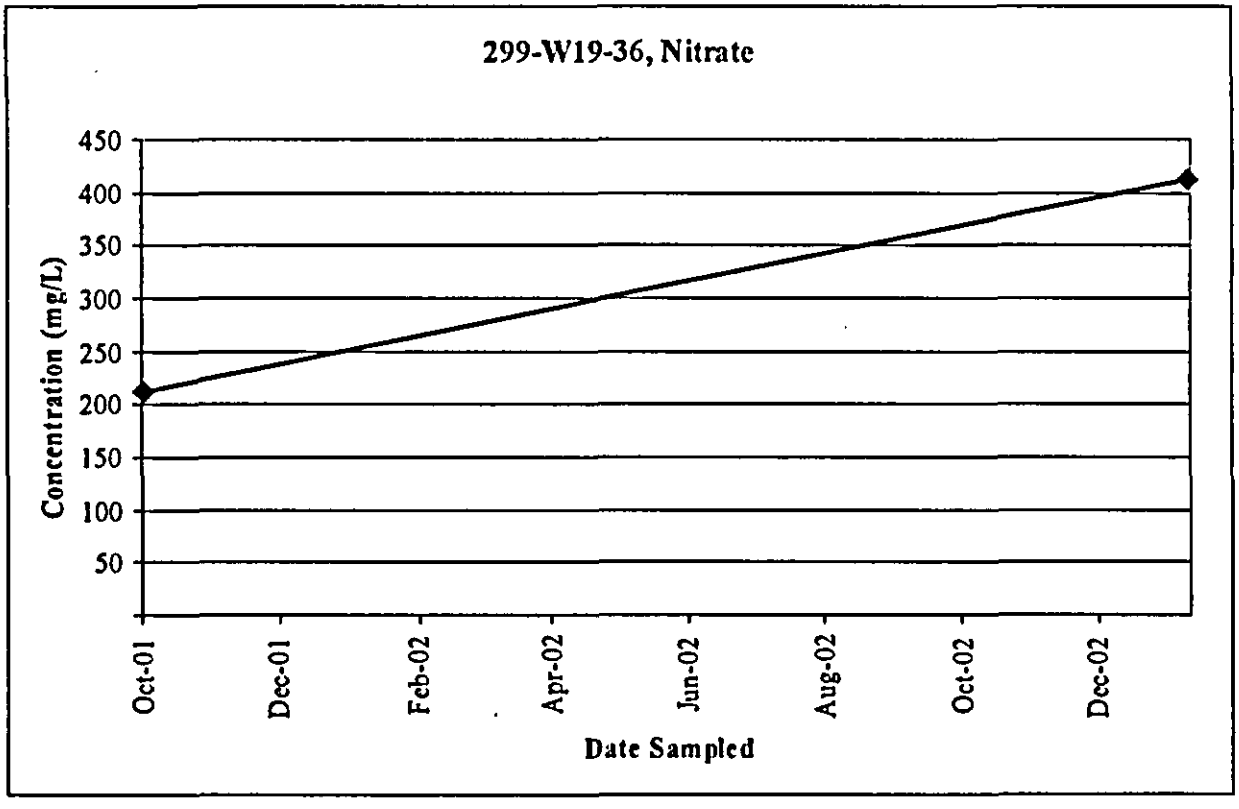

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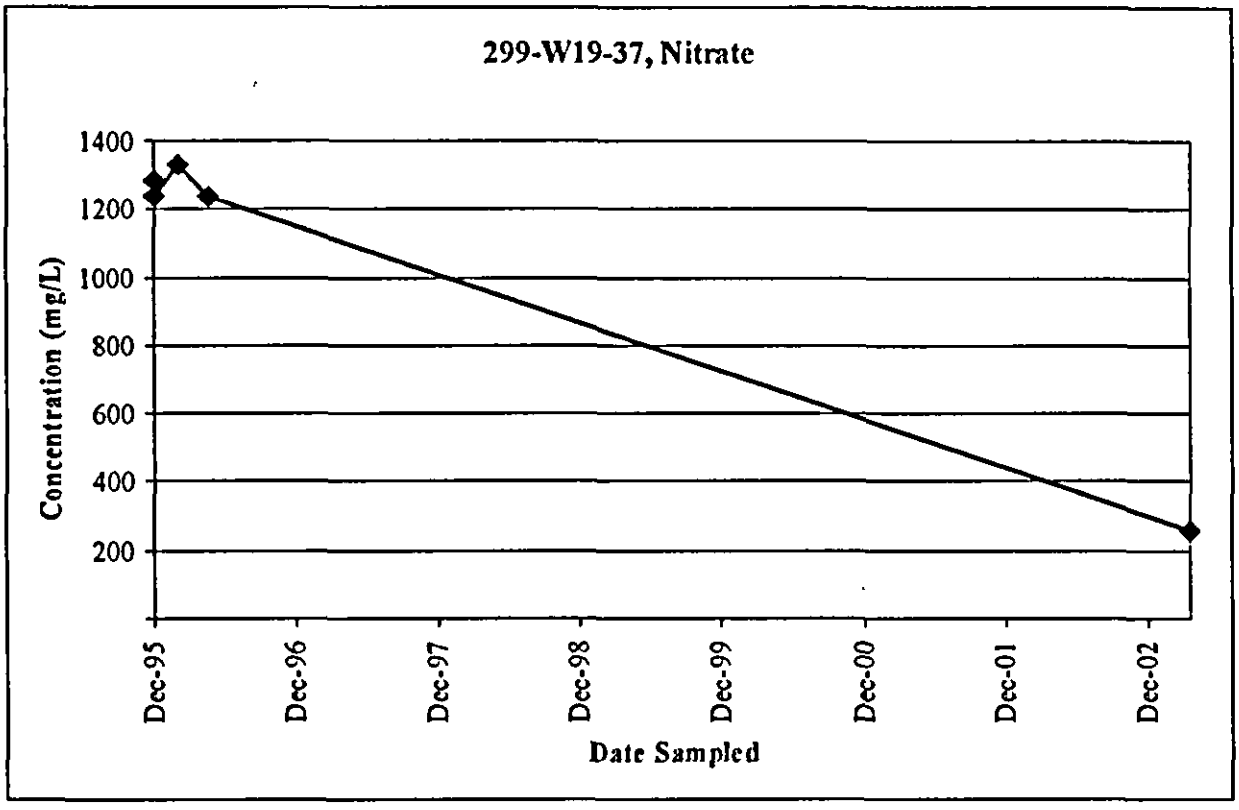

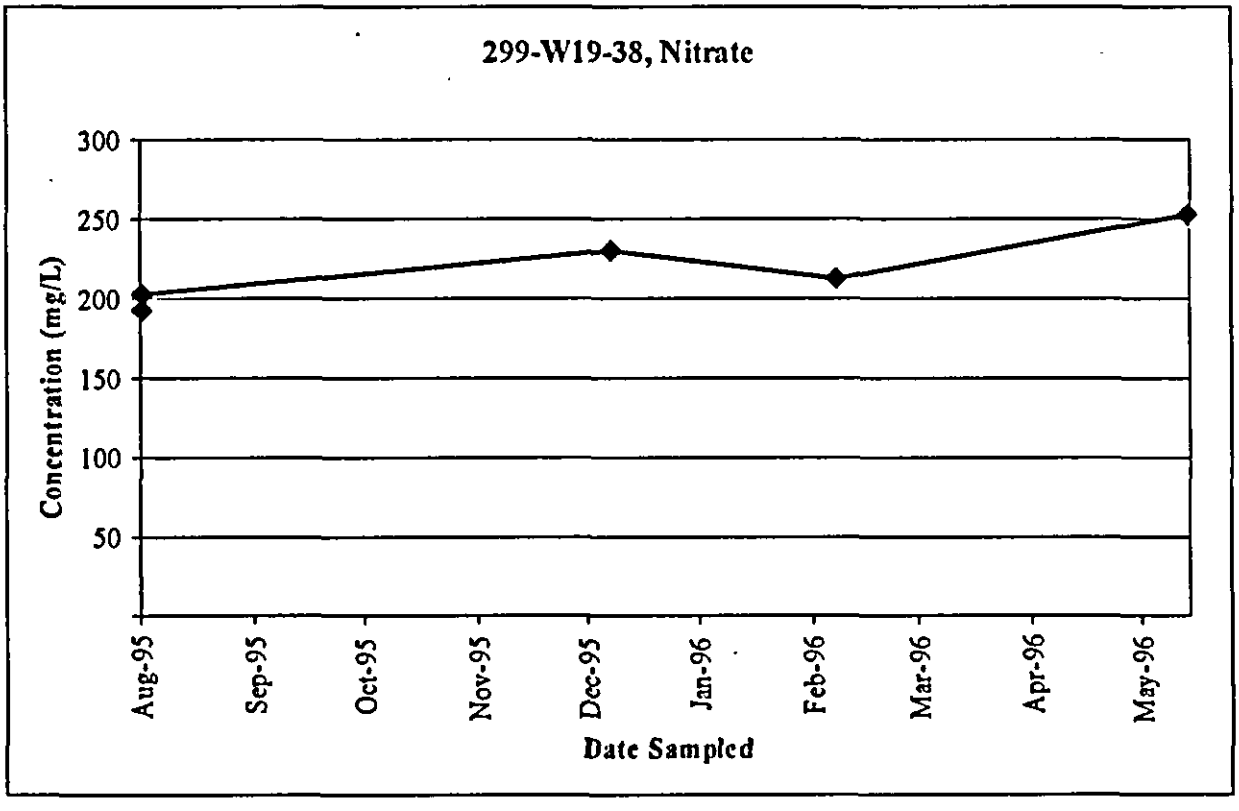

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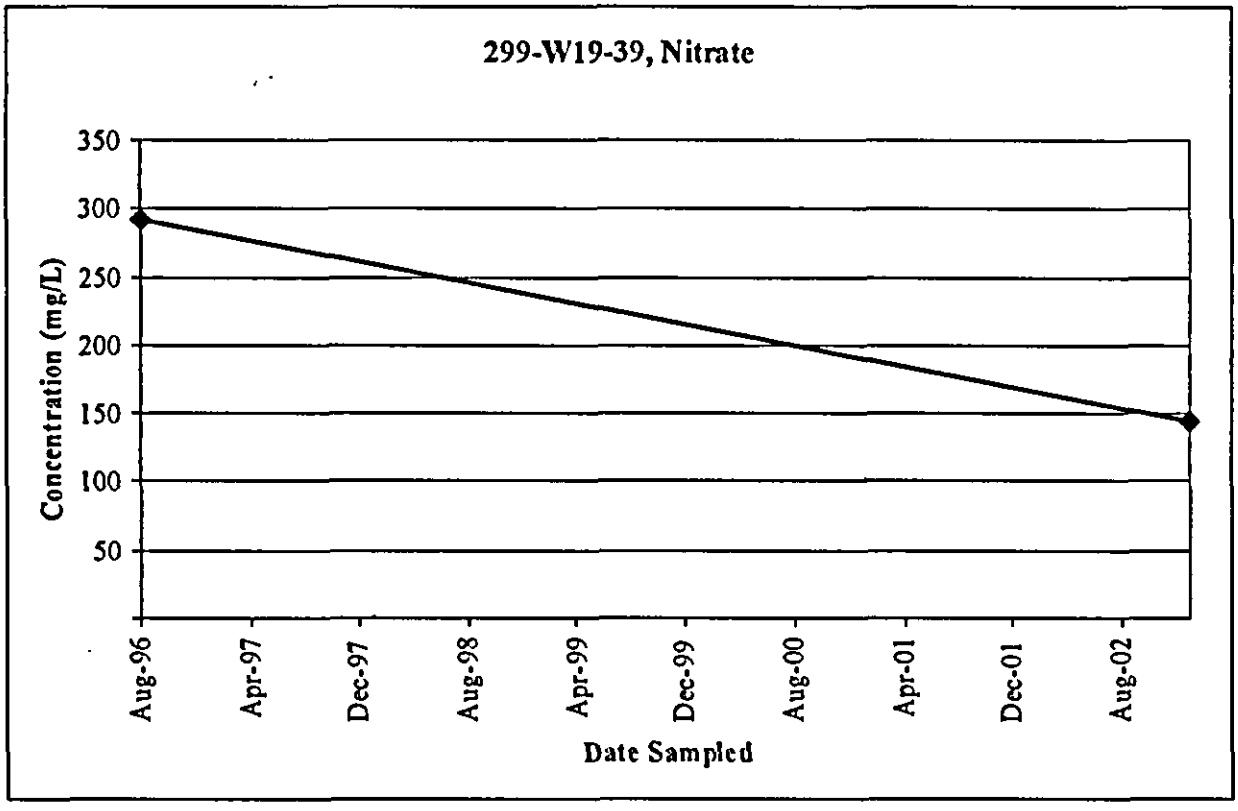


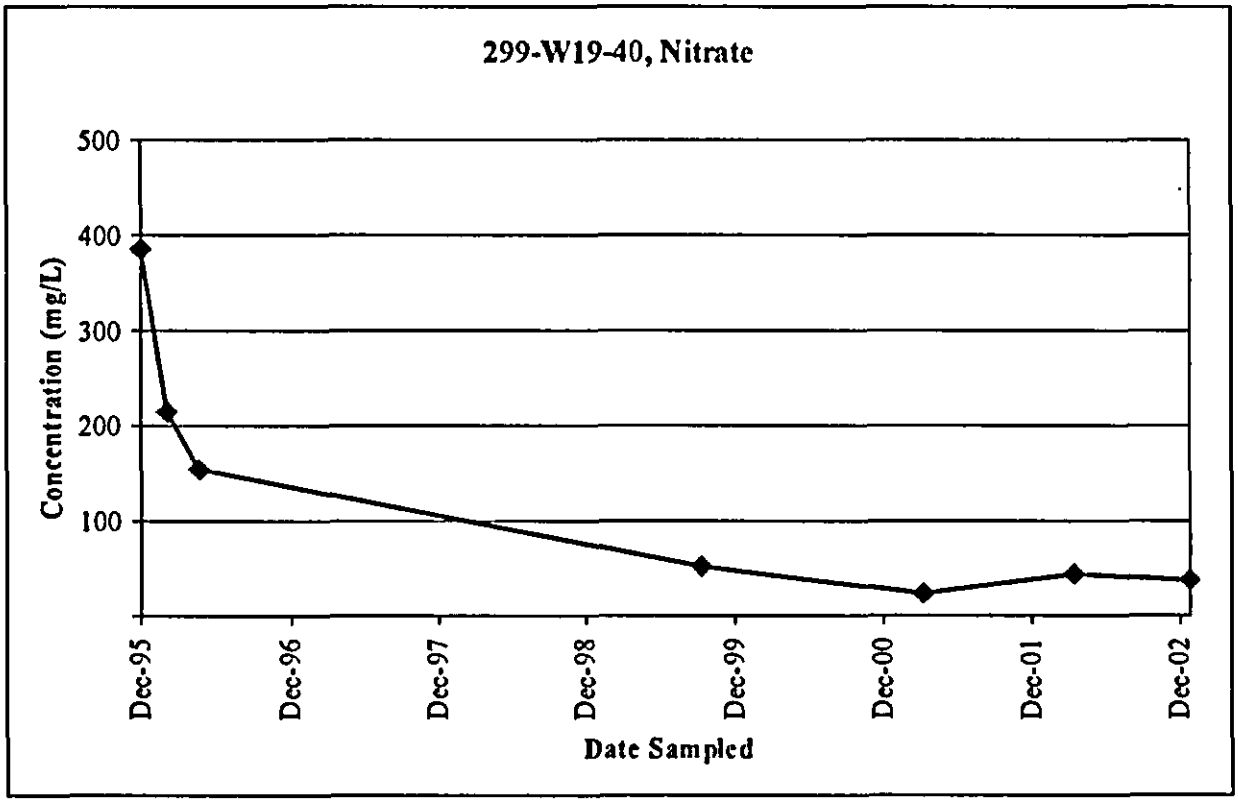
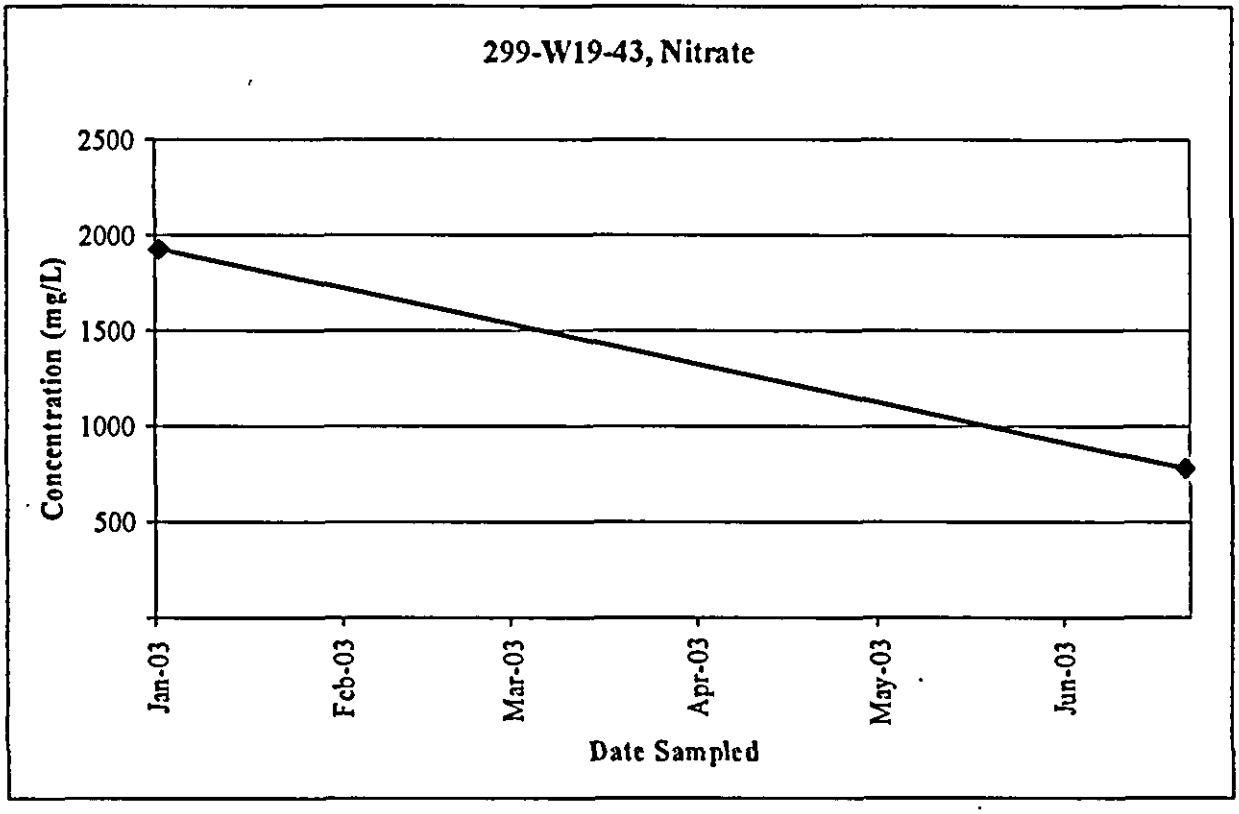


Figure D-4. 200-UP-1 Groundwater Operable Unit, Nitrate Concentration Trends at Selected Monitoring Wells. (11 sheets)



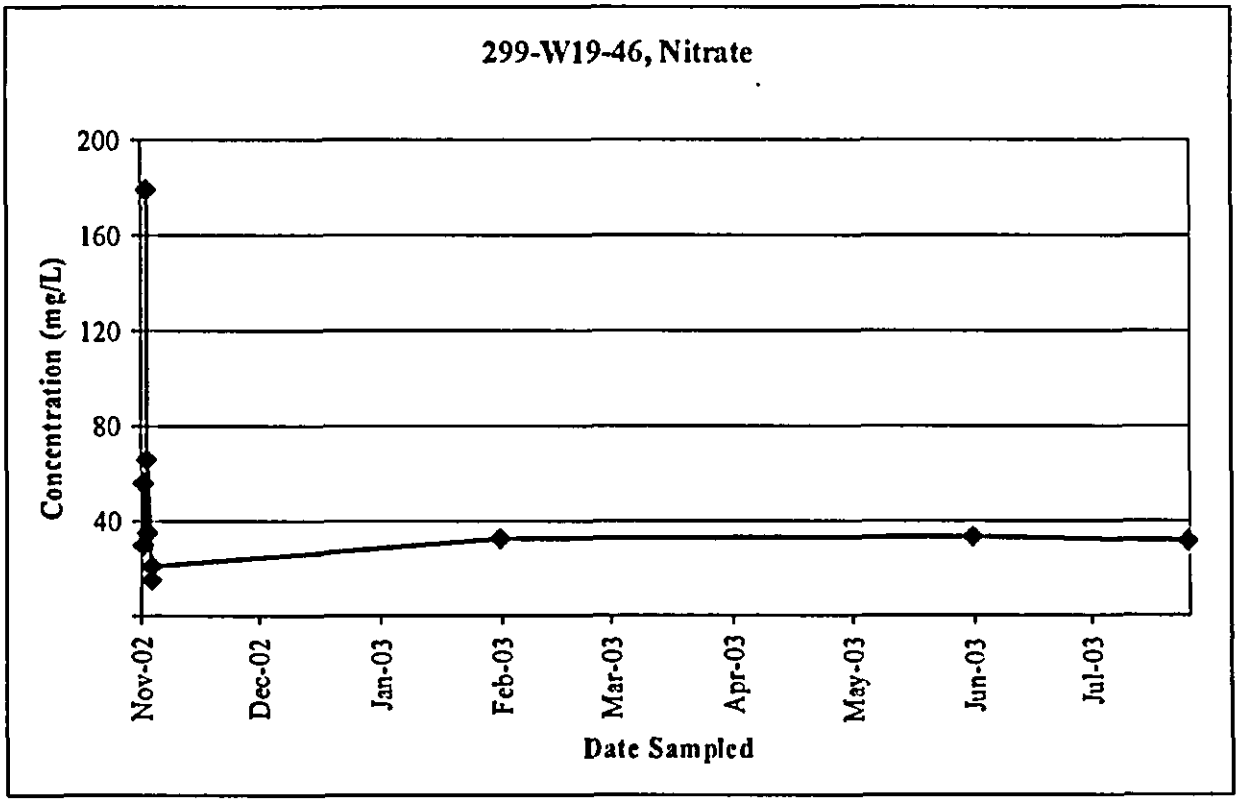
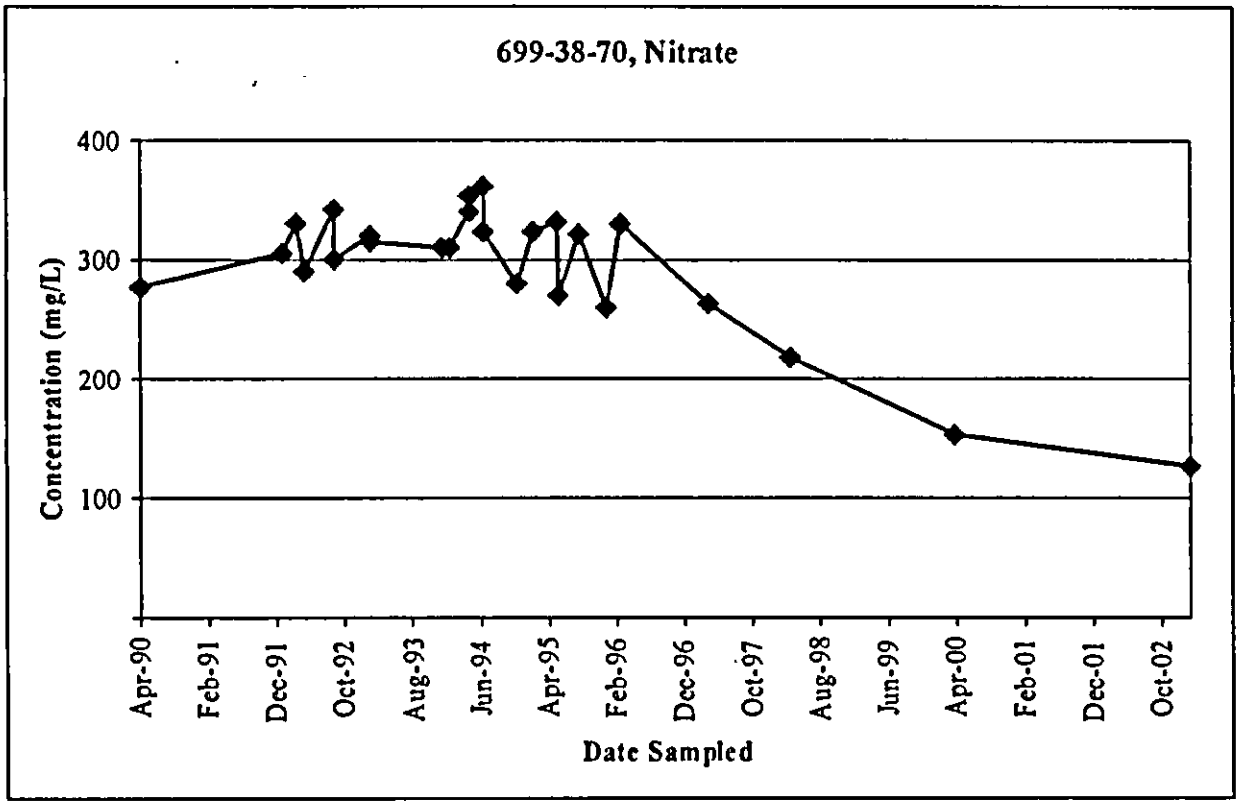


Figure D-4. 200-UP-1 Groundwater Operable Unit, Nitrate Concentration Trends at Selected Monitoring Wells. (11 sheets)



APPENDIX E

NUMERICAL MODELING FOR HYDRAULIC CAPTURE ANALYSIS

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CONTENTS

FIGURES

TERMS

FY	fiscal year
gpm	gallons per minute
OU	operable unit
PNNL	Pacific Northwest National Laboratory

APPENDIX E

NUMERICAL MODELING FOR HYDRAULIC CAPTURE ANALYSIS

Numerical modeling is used to evaluate and predict responses of an aquifer to natural and engineered flow conditions. A capture zone analysis is an application that determines which part of an aquifer is brought into a pumping extraction well system over time. This application is particularly useful for groundwater remediation where extraction and injection wells are used to control movement of a contaminant. Physically, a capture zone is the width of that part of the steady-state cone of depression that is drawn into the pumping well. The zone of influence is the broader area over which flow direction is changed by pumping but does not reach the pumping well.

The time that the system operates and the velocity and direction of regional groundwater flow determine the upgradient extent, or "reach," of pumping at the well. The groundwater model may be applied to design an extraction well system or may be used (as here), to show the area of aquifer swept by the treatment system during a period of operation. A capture zone is depicted as a series of streamlines approaching an extraction well or emanating from an injection well, each streamline depicting the theoretical path of a representative particle of water drawn to, or pushed from, a well.

Model development for the 200 West Area pump-and-treat systems has been discussed in the *200-UP-1 Groundwater Pump-and-Treat Phase I Annual Report* (BHI 1996), *Fiscal Year 1997 Annual Report for the 100-NR-1, 200-UP-1, and 200-ZP-1 Pump-and-Treat Systems and Operable Units* (DOE-RL 1998), and *Fiscal Year 1998 Annual Summary Report for the 200-UP-1, 200-ZP-1, and 100-NR-2 Pump and Treat Operations and Operable Units* (DOE-RL 1999). To improve the performance of the model and the consistency of modeling results for the Hanford Site, hydraulic conductivity and geologic layering data from the Sitewide model developed by Pacific Northwest National Laboratory (PNNL) were incorporated in the areas surrounding the pump-and-treat systems. The PNNL Sitewide model has undergone extensive calibration and review and represents the best available evaluation of Sitewide groundwater flow. While the PNNL Sitewide model is fully three-dimensional and contains hydraulic data for multiple hydrogeologic layers; for the purpose of capture analysis, using three model layers appears to be adequate to represent the flow around the extraction well. Grid spacing for the Sitewide model is 120 m (393.7 ft); thus, near the pump-and-treat systems, the results of the aquifer testing and drawdown analyses were used to refine the model properties.

E1.0 200-UP-1 OPERABLE UNIT NUMERICAL MODELING

Numerical modeling was used to evaluate the effects of interim remedial action on the 200-UP-1 Operable Unit (OU) aquifer during fiscal year 2003 (FY03). Three extraction wells were used during the course of the year. Well 299-W19-39 operated nearly continuously (350 days) throughout FY03, as it has since March 1996. Monitoring well 299-W19-43, installed at the end of FY01, was converted to an extraction well in May 2003 and began continuous operation in July 2003. Well 299-W19-36, converted to an extraction well in December 2001, was changed

back to a monitoring well in May 2003 due to low extraction rates. It was re-equipped for extraction in late FY03 and will be used to improve overall production in FY04.

The areas of capture around wells 299-W19-39, 299-W19-36, and 299-W19-43 during the current FY (Figure E-1) are approximately circular, with an area of about 38,200 m^2 (411,181 ft^2), 7,950 m^2 (85,573 ft^2), and 2,500 m^2 (26,910 ft^2) (radii of about 110 m [360.9 ft], 50 m [164 ft], and 28 m [91.9 ft]) around wells, respectively. The capture zone around well 299-W19-36 is not expected to extend downgradient to well 299-W19-43, where concentrations of both technetium-99 and uranium exceeded the remedial action objective levels during FY02 and the first half of FY03. However, extraction at well 299-W19-43 may extend the capture zone upgradient to well 299-W19-36.

The capture areas shown in Figure E-1 are limited to the approximate capture occurring during the current FY. Prior to FY02, previous reports portrayed the entire area of capture since the beginning of the pump-and-treat operations in 1995. As of September 1999, extraction well 299-W19-39 was depicted as having removed at least one pore volume of groundwater to a depth of about 15 m (49 ft) from the baseline plume area (DOE-RL 2000). Most water extracted after that time probably originated from the area upgradient of the original plume area. Only very limited data are available to evaluate the aquifer conditions upgradient of the original targeted area. There are no wells between the 216-U-1 and 216-U-2 waste disposal cribs and original baseline plume wells (e.g., 299-W19-28 and 299-W19-29). Further complicating the analysis is the injection that occurred in well 299-W19-36 between October 1996 and February 1997 during Phase I pump-and-treat operations. Because of the changes in the pumping (both extraction and injection) and the changes in the plume geometry, the extent of the capture areas shown in Figure E-1 are limited to the approximate capture occurring since FY01. This depiction appears to be more consistent with the current focus of the pump-and-treat operation.

The source of the technetium-99 currently observed in wells 299-W19-36 and 299-W19-43 starting in September 2001 has been attributed to the movement of treated injected water through that part of the soil column once occupied by the elevated groundwater table (DOE-RL 2003). The impact of injecting treated was observed with peaking technetium-99 concentrations at wells 299-W19-28 and 299-W19-29 before they went dry. This same effect is thought to have occurred at well 299-W19-43. Peaking technetium-99 at well 299-W19-36 is thought to have resulted from draining of groundwater mound around the injection well carrying some residual contamination to samples. A driving mechanism for technetium-99 mobilization and transport may still be available from leaking water lines and operation of a sanitary tile field (2607-W5) located near the 216-U-1 and 216-U-2 Cribs.

Uranium is thought to have behaved similarly, as it was likely present in the aquifer near well 299-W19-43 at the start of pump-and-treat operations. While continued pumping in well 299-W19-39 may eventually capture the groundwater around well 299-W19-43, transport of both contaminants to that well (and the consequent reduction in contaminant concentration) may require several years to accomplish. The conversion of monitoring well 299-W19-43 to extraction well in July 2003 with a flow rate of 51 L/min (13.5 gallons per minute [gpm]) has accelerated the process of contaminant removal. For 3 months of operation, the capture zone around this well extended to about an 2,500-m^2 (26,910-ft^2) area.

The technetium-99 concentration trends appear to substantiate the earlier modeling evaluation that extraction well 299-W19-39 removed a pore volume from the original targeted plume area. However, removal of a pore volume of groundwater does not assure complete removal of all contaminants. During FY02, increasing or peaking concentrations at wells 299-W19-36 and 299-W19-43 were increasing or had peaked and were declining. Although the decline at both wells appears to be encouraged by extraction, the response, although quicker, is very similar to that observed at a number of other wells within the baseline plume boundary. The concentration of technetium-99 in wells 299-W19-30, 299-W19-20, and 299-W19-37 (all located upgradient of well 299-W19-39) followed similar peak and decline patterns. The measured technetium-99 concentration in well 299-W19-43 decreased from a high of 22,400 pCi/L in FY02 to less than 4,000 pCi/L in FY03. At well 299-W19-36, technetium-99 concentrations declined from 27,700 pCi/L in November 2000 to an average of 8,915 pCi/L in August 2002, before declining in January 2003 to 4,600 pCi/L.

E2.0 200-ZP-1 OPERABLE UNIT NUMERICAL MODELING

The capture zone analysis evaluates and tracks the effects of the interim remedial action on the aquifer. The extraction well flow lines show that the 200-ZP-1 OU pump-and-treat system is capturing the baseline high-concentration portion of the plume. The flow lines also show that the extraction wells provide a continuous line of hydraulic containment. The flow lines, shown in Figure E-2, represent the travel paths of water particles drawn to extraction wells or driven away from injection wells in the pump-and-treat system by the end of September 2003. The composite of the flow lines around the extraction wells represents the capture area or where the extraction wells have removed a pore volume of groundwater through the upper portion of the aquifer.

Most capture areas around the extraction wells extend into the high-concentration area (greater than 2,000 µg/L) of the baseline June 1996 carbon tetrachloride plume. The capture flow lines (Figure E-2) represent a steady-state approximation of the hydraulic capture of the extraction wells relative to the aquifer conditions existing at the beginning of pumping. Groundwater entering the 1996 Phase II extraction wells during this FY was located near to, or at the end of, the capture flow lines in August 1996, and groundwater entering the Phase III extraction wells was now located at the end of the capture flow lines in August 1997. The capture area around well 299-W15-37 (shown in Figure E-2) represents the area captured before pumping was stopped on January 17, 2001. The capture areas are approximate because of the changing aquifer conditions (the regional decline in the water table coupled with the changing water levels caused by the pumping), changing pumping rates, and the periods of inactivity during shutdowns.

The Phase II extraction wells have operated since August 1996 and exhibit the greatest capture area. Around well 299-W15-33, one pore volume has been removed as far as 220 m (721.8 ft) upgradient and about 100 m (328.1 ft) laterally. Pumping in wells 299-W15-34 and 299-W15-35 creates overlaps in capture zones with that formed at well 299-W15-33. As a result, the capture zones around wells 299-W15-34 and 299-W15-35 extend more to the northwest than they otherwise might. Similarly, the capture zone for well 299-W15-35 also overlaps that of 299-W15-32. This effect is demonstrated by the elevated carbon tetrachloride results at well 299-W15-38. Carbon concentrations have exceeded 2,000 µg/L for most sampling events since December 1996. For well 299-W15-35, one pore volume has been removed as far as 470 m (1,542 ft) upgradient of the well, about 280 m (918.6 ft) laterally, and about 300 m (984 ft) downgradient. The Phase III extraction wells have operated since August 1997.

Pumping at well 299-W15-37 was discontinued because the concentration of carbon tetrachloride in that well was substantially below the remedial action objective level of 2,000 µg/L. Continued operation of that well might have resulted in spreading the high-concentration area of the plume. The shape and dimensions of the capture zones around wells 299-W15-32 and 299-W15-36 are similar to one another. The capture zones extend upgradient about 360 to 350 m (1,181.1 to 1,148.3 ft) and about 100 to 220 m (328.1 to 721.8 ft) laterally, respectively.

A recommendation to shut down well 299-W15-36 for similar reasons is under consideration, if replacement wells for 299-W15-32 and 299-W15-33 can produce enough water to equal the extraction system's goal of 567.8 L/min (150 gpm).

Water injected into well 299-W15-29 has displaced one pore volume as far as 440 m (1,443.6 ft) from the well. Water injected into the other two injection wells currently operating (wells 299-W18-36 and 299-W18-37) has displaced one pore volume of groundwater within approximately 145 m (475.7 ft) of those wells.

E3.0 CONCLUSION

From the standpoint of designing a pump-and-treat system, capture zone modeling is essential to help establish and evaluate a well field that is capable of containing or removing a known contaminant plume. Injection wells may be added to hasten the flow to the extraction wells. As a check on system performance, the model is run according to known operating parameters (i.e., extraction and injection rates at wells) to depict how the two are functioning at containing plume movement. Plume location, as determined by regular sampling at monitoring wells and contouring of the results, establishes plume location, size, and mass. A comparison between plume boundaries and the well field capture zone leads to an assessment of how efficiently the treatment system is containing the plume, or where contaminants may be beyond the influence of the well field. The model thus provides a check on the effectiveness of the remedial action and indicates how well the system is meeting the Records of Decision (EPA et al. 1995, 1997) for containing the plumes.

E4.0 REFERENCES

BHI, 1996, *200-UP-1 Groundwater Pump-and-Treat Phase I Annual Report*, BHI-00951, Rev. 0 , Bechtel Hanford, Inc., Richland, Washington.

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EPA, Ecology, and DOE, 1997, *Record of Decision for the 200-UP-1 Interim Remedial Measure*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington.

Figure E-1. 200-UP-1 Operable Unit Area of Hydraulic Capture Through September 2003.

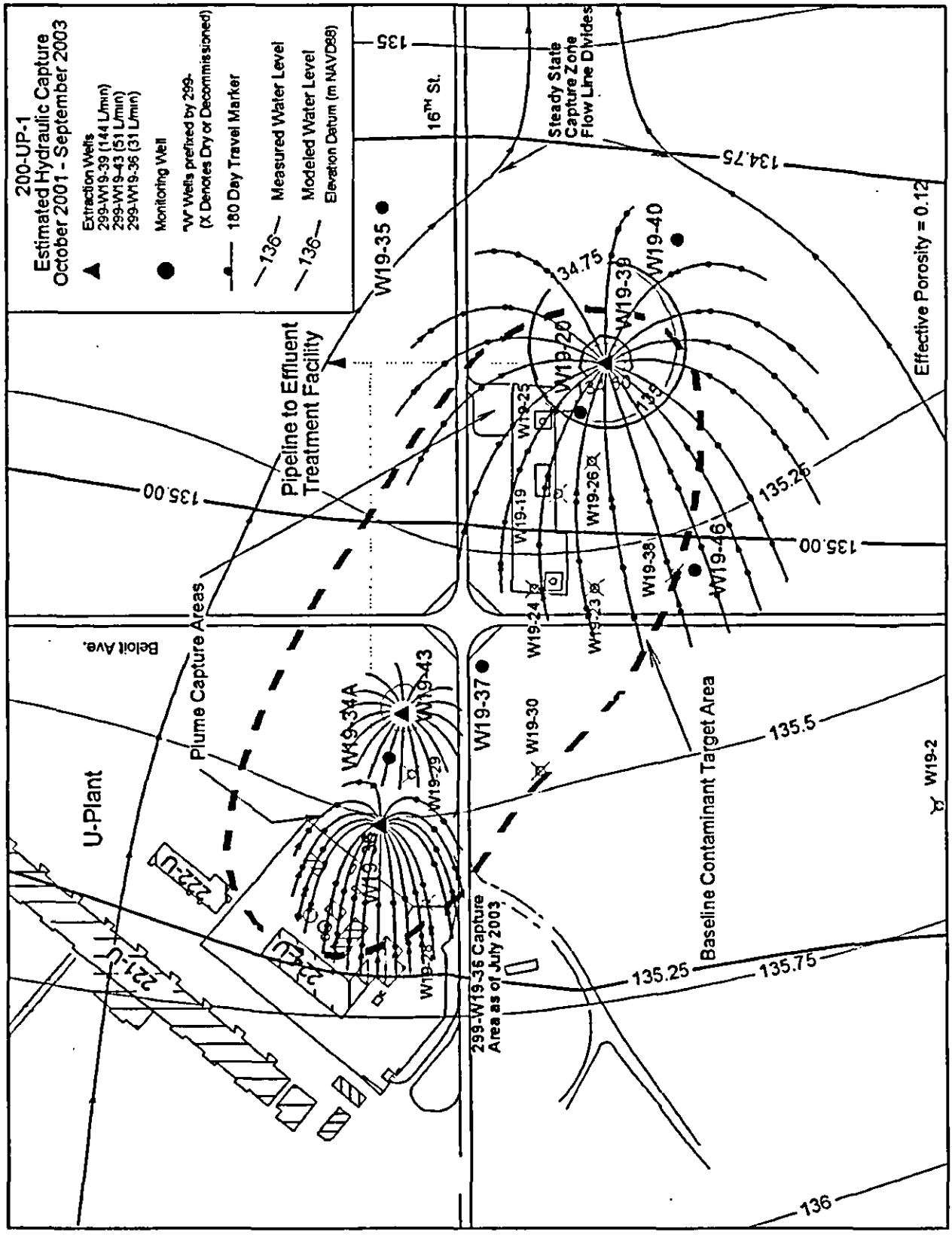
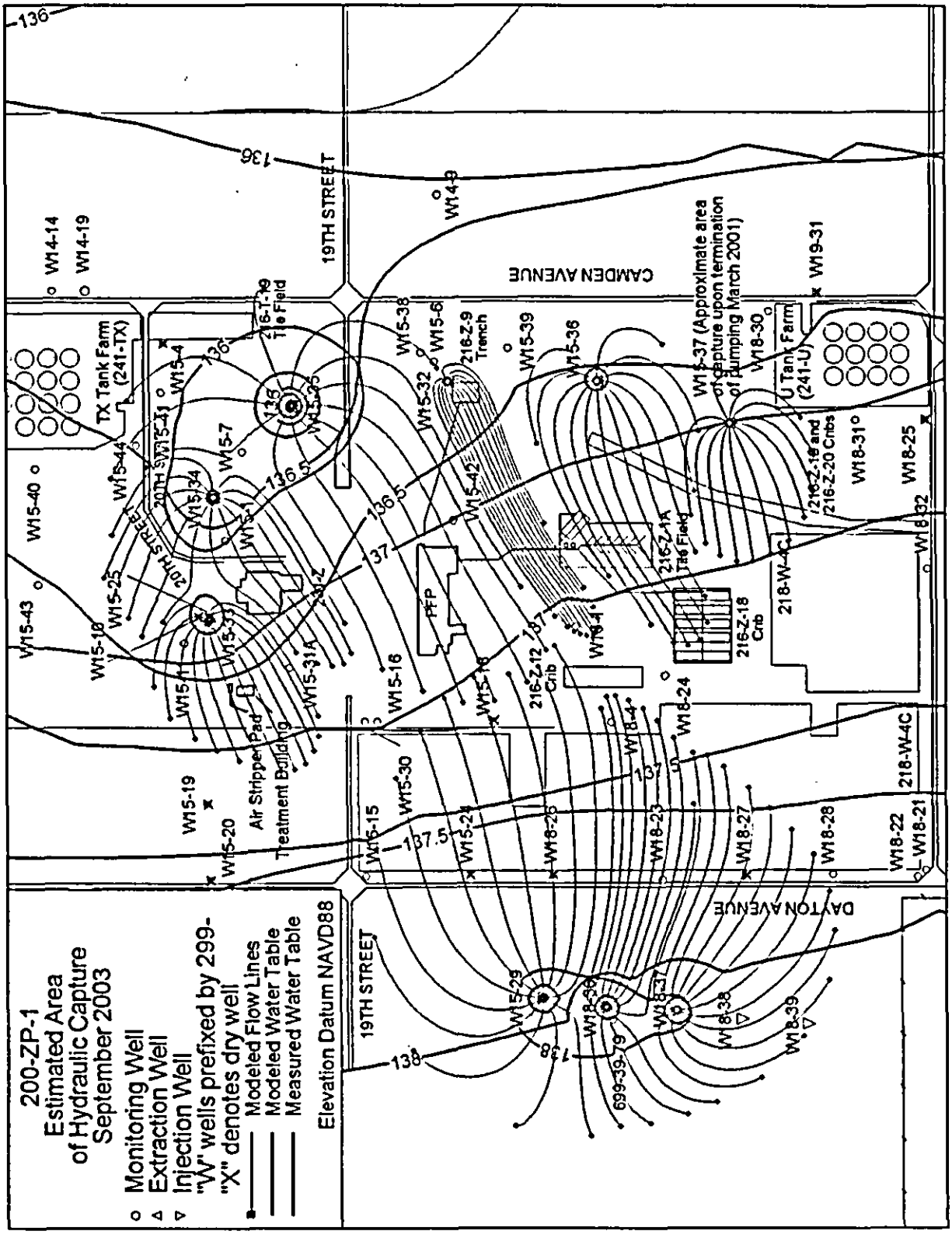


Figure E-2. 200-ZP-1 Operable Unit Area of Hydraulic Capture Through September 2003.



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APPENDIX F

TECHNETIUM AT WELL 299-W23-19

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CONTENTS

FIGURES

TABLE

TERMS

DOE	U.S. Department of Energy
ETF	Effluent Treatment Facility
FY	fiscal year
gpm	gallons per minute
OU	operable unit

APPENDIX F

TECHNETIUM-99 AT 299-W23-19

F1.0 HISTORICAL DEVELOPMENT

Groundwater monitoring well 299-W23-19 was drilled near the southwest corner of the SX Tank Farm between August and September 1999, sampled initially in October, and completed in November 1999. The boring was intended only for characterization of the vadose zone, but high concentrations of technetium-99 were found in groundwater grab samples. A decision was made to install a well for groundwater monitoring. The first analytical results for technetium-99 averaged 45,000 pCi/L. Following that, concentrations ranged between 29,500 and 99,700 pCi/L, both since inception of sampling and through fiscal year 2002 (FY02). In FY03, technetium-99 concentrations peaked at 188,000 pCi/L, then began declining (Figure F-1). This plume and the well are located in the 200-UP-1 Groundwater Operable Unit (OU).

- The elevated concentrations were noted by the Washington State Department of Ecology in a May 31, 2001, letter to the U.S. Department of Energy (DOE) (Ecology 2001), which requested an evaluation of interim measures for the groundwater. The DOE authorized an evaluation by CH2M HILL Hanford Group, Inc., which examined three options for groundwater treatment: (1) using a skid-mounted pump-and-treat system with reinjection of treated water; (2) hauling pumped groundwater in tanker trucks to the Effluent Treatment Facility (ETF) for treatment; and (3) constructing a pipeline to the 200-UP-1 pump-and-treat site, where the pipe could be tied in to the existing pipeline for conveyance to the ETF.
- The study calculated the cost of construction and operation and also identified regulatory issues that potentially hampered each of the three options. The technical feasibility of the three was predicated upon an unknown but low, sustainable groundwater extraction rate from well 299-W23-19. Administrative feasibility issues varied with individual options and included: permitting reinjection of groundwater for option #1; determining if waste streams and facilities in options #2 and #3 were regulated under the *Resource Conservation and Recovery Act of 1976* or the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*; determining if groundwater sent to the ETF and/or the 200-UP-1 OU pipeline could be combined for use with existing groundwater streams; and determining whether the ETF could handle a sustained flow of 208 to 227 L/min (55 to 60 gallons per minute [gpm]).
- A geohydrologic analysis of the technetium-99 plume at well 299-W23-19 was conducted and included a pumping test, plus numerical modeling of plume configuration and response to pumping. The pumping test was conducted between December 13 and 20, 2001. The results and analysis are reported in *Technetium-99 in Groundwater at Hanford Well 299-W23-19: Options Analysis and Recommended Action Report* (CHG 2002). The data indicated that a sustainable extraction rate of only 11 to 13 L/min (3 to 3.5 gpm) was possible from the well despite it being screened over an 8.2-m (27-ft)-thick interval. Sampling of groundwater from the well during a 72-hour pump test,

coupled with specific conductance meter readings, indicated a fairly uniform distribution of technetium-99 concentrations around the well.

- Numerical modeling was conducted (CHG 2002) to quantify the effects of extraction on the aquifer and contaminant plume and to evaluate the effects of an interim remedial measure. Many of the aquifer properties were calculated with pumping test-based data, while other properties were gathered from previous testing at nearby wells. Numerical modeling based on data from the 72-hour pump test, indicated a capture zone extending approximately 30 m (100 ft) around the well (Figure F-2). Groundwater flow velocities under constant pumping indicated that the area beneath tank farms would be treated within 2 years. The 9,000 µg/L contour of the technetium-99 plume was compared with the downgradient reach of the capture zone and was found to be mostly contained within the capture zone and beneath the boundary of the SX Tank Farms. Less concentrated portions of the plume exceeded the boundary of both the capture zone and the tank farms and were beyond the range of interim remediation options at well 299-W23-19. Note that the capture zone shown in Figure F-2 does not represent the capture zone of a quarterly, extended purge when sampling at the well.
- An additional purpose of the CHG report (CHG 2002) was to further evaluate the interim remedial measures at well 299-W23-19 following the groundwater pump test. Two nontraditional remedial measures also were identified and evaluated. The first measure, impermeable barriers (i.e., grout curtain) coupled with a pump-and-treat operation, was regarded as being cost prohibitive for the deep unconfined aquifer conditions at the well. The second approach, permeable reactive barriers using In Situ Redox Manipulation, in situ gaseous reduction, or in situ apatite sorption techniques/additives were under development; however, they were not considered as suitable for use at their current levels of development. Each technique involved placing contaminant-specific additives in boreholes drilled into the aquifer, which then capture and isolate the target contaminant. Although additives have been proven effective for technetium-99 in bench-scale tests for each of the reactive barrier techniques, and have been implemented for the first two of the three in the field for other contaminants, the technology was not regarded as ready for use for technetium-99 treatment at well 299-W23-19.
- Following submittal of *Technetium-99 in Groundwater at Hanford Well 299-W23-19: Options Analysis and Recommended Action Report* (CHG 2002), agreement was reached that both a pump-and-treat system and the pipeline to the 200-UP-1 pump-and-treat system were not effective solutions. The DOE and the regulators agreed that the well would be purged quarterly for a day during sampling and the purgewater would be treated at the ETF. To expedite the quarterly sampling and purgewater collection, CH2M Hill Hanford, Inc. constructed two vaults, one over well 299-W23-19 and one over a remote vault outside of the 241-SX Tank Farm fence line. A 13.5-m (44-ft) connecting pipeline carried the well casing and instrumentation leads to the remote vault. The design allows ready access to the well and its associated downhole instrumentation from outside the fence line, thereby eliminating coordination and access problems with the tank farm. The system was constructed during the second quarter of FY03 and was ready for use for the March 12, 2003, sampling event.

F2.0 STATUS FOR FISCAL YEAR 2003

The quantities of water pumped and waste treated is presented in this appendix and in Section 2.8 of the main text of this document. For FY03, the well was sampled five times, the last three of which were accompanied by purgewater collection and treatment. The collected groundwater is taken by tanker to the Liquid Effluent Retention Facility where it is unloaded and combined with groundwater received from the 200-UP-1 extraction wells. The combined waters are then treated at the ETF. The trend plot for technetium-99 since the start of monitoring is presented in Figure F-1. The figure shows a peak concentration in January 2003 of 188,000 pCi/L, followed by a substantial decline to 74,300 pCi/L in September 2003.

The analytical results from the individual sampling events are assumed to be representative over the duration of pumping. The ETF reported 100% removal of technetium-99 throughout FY03. From this information, the technetium-99 curie content was calculated and converted to a mass value using the specific activity value of 0.017 Ci/g. Table F-1 presents data on the accumulated volume of waste and the concentration of the initial sample. As shown in Table F-1, a total of approximately 0.00114 Ci of technetium-99 have been recovered, or 0.067 g, in 10,763 L (2,843.3 gal) of water.

In general, the declining concentrations of technetium-99 suggest that the plume is moving beyond the range of quarterly extraction activities. Downgradient wells 299-W22-46 and 299-W22-50 averaged 7,333 pCi/L and 9,453 pCi/L, respectively, for FY03, which are increases from 5,916 and 5,588 pCi/L, respectively, reported in FY02.

The March 12, 2003, groundwater collection did not meet the desired goal of +3,785 L (+1,000 gal) of purgewater. One acceptance criterion imposed by the ETF is that the water to be treated should contain particles no larger than 5 microns. Filters on the purgewater truck clogged during pumping and limited the total groundwater extracted to 2,722 L (719 gal). The filtration system was modified and extracted volumes have since surpassed the +3,785 L (+1,000 gal) goal. The *Hanford Site Groundwater Annual Report for Fiscal Year 2003* (PNNL 2004) presents a more detailed discussion of technetium-99 at this well.

F3.0 REFERENCES

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Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601, et seq.

Ecology, 2001, *Washington State Department of Ecology Directs Office of River Protection to Evaluate Interim Measures to Remediate High Level of Technetium-99 in Groundwater Associated with SX Waste Management Area Well 299-W23-19*, Letter No. 0102661, from N. H. Uziemblo to H. L. Boston, ORP, dated May 31, 2001, Washington State Department of Ecology, Olympia, Washington.

PNNL, 2004, *Hanford Groundwater Annual Report for Fiscal Year 2003*, PNNL-14585, Pacific Northwest National Laboratory, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq.

Figure F-1. Plot of Fiscal Year 2003 Technetium Concentrations at Well 299-W23-19.

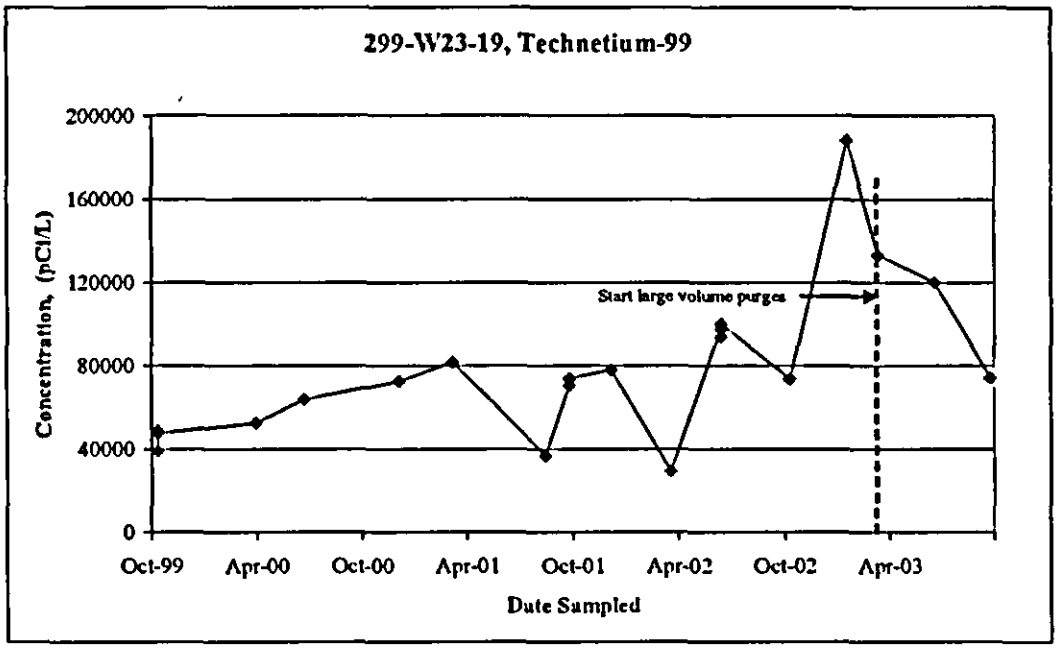

Figure F-2. Technetium-99 Groundwater Plume and Capture Zone at Well 299-W23-19.

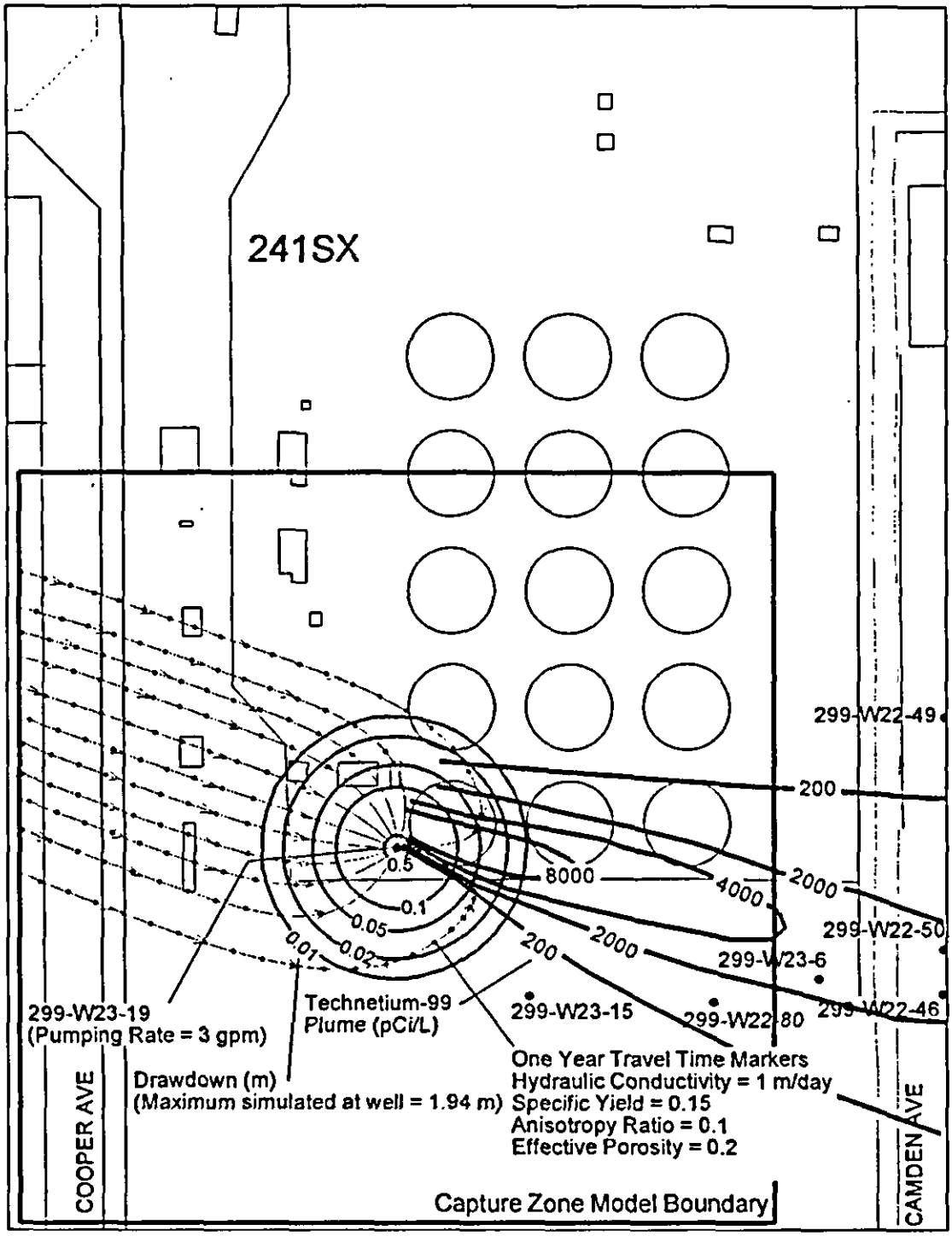

Table F-1. Accumulated Volume of Waste and Concentration of Initial Technetium-99 Samples.

Date of Sampling	Groundwater Pumped, L (gal)	Technetium-99 Concentration (μg/L)	Curies of Technetium-99	Mass of Technetium-99 (g)[a]
March 12, 2003	2,722 (719)	133,000	0.00036	0.021
June 18, 2003	4,028 (1,064)	120,000	0.00048	0.028
September 23, 2003	4,013 (1,060)	74,300	0.00030	0.018

[a] Specific activity of technetium-99 is 0.017 Ci/g, or 58.7 g/Ci.

APPENDIX G

QUALITY ASSURANCE/QUALITY CONTROL

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CONTENTS

TABLES

TERMS

CRDL	contract-required detection limit
EPA	U.S. Environmental Protection Agency
FY	fiscal year
MDL	minimum detection limit
N/A	not applicable
QC	quality control
RER	relative error ratio
RPD	relative percent difference
TCE	trichloroethene

APPENDIX F

QUALITY ASSURANCE/QUALITY CONTROL

Field replicates, offsite laboratory replicates, field/offsite laboratory splits, and offsite laboratory splits are quality control (QC) samples used to assess the precision of chemical analyses.

Establishing precision of samples analyzed by field screening consisted of comparing analyses of replicates and calculating the relative percent difference (RPD) as follows:

$$RPD = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2) / 2}$$

where C_1 is the larger of the two observed concentrations or activities and C_2 is the smaller of the two observed concentrations or activities. The U.S. Environmental Protection Agency (EPA) issued guidelines (EPA 1988) applicable to field analytical techniques in which a 20% RPD was regarded as indicating good precision. These guidelines are not applicable to other comparisons between field and laboratory results but are used here for comparison. The RPDs were not calculated for nondetects or sample pairs with different laboratory qualifiers.

A second statistical method to evaluate precision is with the relative error ratio (RER) test, which is calculated by the following equation:

$$RER = \frac{|Result1 - Result2|}{\sqrt{(Error1)^2 + (Error2)^2}}$$

where the error is total analytical error (propagated error or counting error) reported by the laboratory for each of the data pair. This test is useful for analytical values within five times the minimum detection limit. A value from this calculation falling within an RER of 1 to 1.5 is regarded as indicating satisfactory precision.

G1.0 200-UP-1 OPERABLE UNIT QUALITY ASSURANCE/QUALITY CONTROL

The 200-UP-1 offsite laboratory replicate results for uranium, technetium-99, carbon tetrachloride, trichloroethene (TCE), and chloroform QC sample analyses are presented in Table G-1 by sample number and result. The replicate samples were taken at wells identified in the *Sampling and Analysis Plan for the 200-UP-1 Groundwater Monitoring Well Network* (DOE-RL 2002) but did not include monitoring wells around the baseline plume boundary.

G1.1 OFFSITE LABORATORY REPLICATES

- **Uranium:** Uranium replicates were analyzed by offsite laboratories using laser phosphorimetry. The RPDs ranged from 3.4% to 54.1%. The RPD exceedence may be explained by the fact that the replicate pair value concentrations were within five times the detection level. Concentrations within five times of the detection level are prone to greater variability due to unavoidable analytical errors. Calculating the RER of the data pair resulted in a value of 3.28; thus, the two results are different.

- **Technetium-99:** Technetium-99 replicates were analyzed by offsite laboratories using a liquid scintillation counter. The RPDs ranged from 8.9% to 25%. Two of three technetium-99 sample replicate pairs exceeded 20% RPD. The 66% rate of RPD guideline exceedences is difficult to evaluate.

  For the two samples, concentrations were greater than five times the minimum detection limit (MDL), so RER values were calculated. One of the technetium-99 pairs from well 299-W22-20, at 116 µg/L and 90.2 µg/L, resulted in an RER value of 1.23, indicating a satisfactory precision of data. The second pair of data at well 299-W22-46, at 7,060 pCi/L and 5,770 pCi/L, yielded an RER of 2.19; therefore, the results are different.

- **Carbon tetrachloride, chloroform, and TCE:** These replicates were analyzed using a gas chromatograph. Six of nine replicate sample pairs were suitable for RPD calculations and all RPDs ranged between 0 to 16.7%. Using this criterion, the RPD range for volatile organic analytes appears reasonable.

G2.0 200-ZP-1 OPERABLE UNIT QUALITY ASSURANCE/QUALITY CONTROL

The 200-ZP-1 field replicate, offsite laboratory replicate and field-laboratory split results for carbon tetrachloride, TCE, and chloroform QC sample analyses are presented in Table G-2 by sample number and result. All samples were analyzed in the field using a gas chromatograph and offsite using EPA Method 8260 (SW-846 [EPA 1997]).

G2.1 FIELD REPLICATES

- **Carbon tetrachloride, chloroform, and TCE:** These replicates were analyzed in the field using a gas chromatograph. The RPDs ranged from 0 to 9.5%. The EPA's functional guidelines for field replicates is ±20% (EPA 1988), and all 42 replicate pairs met the guideline.

G2.2 OFFSITE LABORATORY REPLICATES

- **Carbon tetrachloride, chloroform, and TCE:** Twenty-seven offsite laboratory replicate sample pairs were analyzed, of which 14 were not tested for RPD because they contained some form of laboratory qualifier. Of the remaining 13 samples, only one exceeded an RPD of 20%. Calculation of the RER was not performed because the sample data did not possess a total analytical error value.

G2.3 SPLITS

- **Carbon tetrachloride, chloroform, and TCE:** These samples were analyzed in the field using a gas chromatograph and offsite using EPA Method 8260 (SW-846 [EPA 1997]). The range of RPDs was 0 to 173.8% for the 28 splits analyzed. Although there is no EPA functional guideline for split samples, the RPD calculation was performed. Six of seven carbon tetrachloride data pairs and five of six TCE data pairs exceeded the RPD guideline value of 20%. The RER values were not calculated because total error data was not reported.

- **Carbon tetrachloride and TCE:** An interesting phenomenon has been observed in variations between offsite laboratories and field testing results. Although not evident from the data in Table G-2, a general correlation between greater holding time for samples at offsite laboratories and lower carbon tetrachloride concentrations is known from fiscal year 2002 (FY02) data (DOE-RL 2003). Although none of the holding times exceeded the 14-day limit for volatile organic analysis in FY02, those samples with distinctly longer holding times showed a greater difference between field and laboratory analyses than the samples with shorter holding time. Available holding time data received for FY03 carbon tetrachloride offsite laboratory samples are presented in Table G-3. See Table G-2, sheet 3 of 3, for a comparison of field versus laboratory analytical values.

G3.0 REFERENCES

DOE-RL, 2002, *Sampling and Analysis Plan for the 200-UP-1 Groundwater Monitoring Well Network*, DOE/RL-2002-10, Rev. 0, U. S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2003, *Fiscal Year 2002 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*, DOE/RL-2002-67, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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EPA, 1997, *Test Methods for Evaluation Solid Waste, Physical/Chemical Methods*, SW-846, 3rd edition (as amended by Update I [July 1992], Update IIA [August 1993], Update IIB [January 1995], and Update III), U.S. Environmental Protection Agency, Washington, D.C.

Table G-1. Quality Control Results for 200-UP-1 Operable Unit Sampling.

Sample Number	Value	Sample Number	Value	RPD%	CRDL Detection, Soil	
Offsite Laboratory Replicates						
Carbon Tetrachloride (µg/L)					5	
B17457	110(D)	B17453	110(D)	0.0		
B16B95	1	B16B94	1.1	9.5		
B16JX2	11	B16JX1	13	16.7		
Trichloroethene (µg/L)						
B17453	0.23(J)	B17457	0.2(J)	N/A	5	
B16B94	11	B16B95	11	0.0		
B16JX1	0.16(U)	B16JX2	0.16(U)	N/A		
Chloroform (µg/L)						
B17453	3.8	B17457	3.8	0.0	5	
B16B95	5.4	B16B94	5.3	1.9		
B16JX2	1.7(J)	B16JX1	2(J)	N/A		
Uranium (µg/L)					1	
B17455	21.3(B)	B17454	20.8(B)	N/A		
B16B93	10.3	B16B92	9.62	6.8		
B16JW9	3.44	B16JX0	5.99	54.1		299-W22-46
B16YT0	6.81	B16YR9	6.58	3.4		
Technetium-99 (pCi/L)					15	
B16B93	116	B16B92	90.2	25.0		299-W22-20
B16JX0	7,500	B16JW9	6,860	8.9		
B16YT0	5,770	B16YR9	7,060	20.1		299-W22-46

(D) = diluted
(J) = estimated
(U) = undetected
(B) = result ≥ two times the minimum detectable activity
CRDL = contract-required detection limit
N/A = not applicable
RPD = relative percent difference

Table G-2. Quality Control Results for 200-ZP-1 Operable Unit Sampling. (3 sheets)

Sample Number	Value	Sample Number	Value	RPD (%)
Field Replicates				
Carbon Tetrachloride (µg/L)				
B15RJ1	2,900	B13NK2	2,800	3.5
B15RN2	2,500	B15RN1	2,400	4.1
B15RL1	5,300	B15RL2	5,200	1.9
B15RP0	3,000	B15RP1	3,000	0.0
B13NJ0	5,500	B13NJ1	5,600	1.8
B15RJ8	5,500	B15RJ9	5,400	1.8
B15RL8	5,500	B15RL7	5,400	1.8
B13NJ6	3,400	B13NJ7	3,500	2.9
B15RK4	3,300	B15RK3	3,100	6.3
B15RM4	3,500	B15RM5	3,400	2.9
B15RR4	3,200	B15RR5	3,300	3.1
B15RJ7	1,100	B15RJ6	1,100	0.0
B15RL0	940	B15RK9	960	2.1
B15RN9	1,100	B15RN8	1,100	0.0
Trichloroethene (µg/L)				
B13NK2	4.5	B15RJ1	4.6	2.2
B15RN1	4.1	B15RN2	4.3	4.8
B15RL1	12	B15RL2	12	0.0
B15RP0	2.5	B15RP1	2.3	8.3
B13NJ0	11	B13NJ1	12	8.7
B15RJ8	10	B15RJ9	10	0.0
B15RL8	18	B15RL7	18	0.0
B13NJ7	11	B13NJ6	10	9.5
B15RK4	9.3	B15RK3	8.9	4.4
B15RM4	11	B15RM5	11	0.0
B15RR5	10	B15RR4	10	0.0
B15RJ6	2(U)	B15RJ7	2(U)	N/A
B15RK9	2.2	B15RL0	2.1	4.7
B15RN9	2.8	B15RN8	2.7	3.6
Chloroform (µg/L)				
B15RJ1	20	B13NK2	20	0.0
B15RN1	20	B15RN2	21	4.9
B15RL1	25	B15RL2	24	4.1
B15RP0	12	B15RP1	12	0.0
B13NJ1	23	B13NJ0	23	0.0
B15RJ8	24	B15RJ9	23	4.3
B15RL7	31	B15RL8	30	3.3
B13NJ7	19	B13NJ6	18	5.4
B15RK3	17	B15RK4	17	0.0

Table G-2. Quality Control Results for 200-ZP-1 Operable Unit Sampling. (3 sheets)

Sample Number	Value	Sample Number	Value	RPD (%)
B15RM4	18	B15RM5	18	0.0
B15RR5	16	B15RR4	16	0.0
B15RJ7	19	B15RJ6	19	0.0
B15RL0	18	B15RK9	19	5.4
B15RN8	19	B15RN9	20	5.1
Offsite Laboratory Replicates				
Carbon Tetrachloride (µg/L)				
B169T3	2,600(D)	B169T1	2,500(D)	N/A
B173F8	12	B173F4	12	0.0
B17470	3,400(D)	B17469	3,500(D)	N/A
B16W50	1,400(D)	B16VY7	1,400(D)	N/A
B16771	0.15(UN)	B16767	0.15(UN)	N/A
B16JX1	13	B16JX2	11	16.7
B16X03	1,600(D)	B16X02	1,400(D)	N/A
B15T18	3,100	B15T17	3,941	23.9
B167P1	2,218	B167P2	2,276.6	2.6
Chloroform (µg/L)				
B169T3	11	B169T1	12	8.7
B173F8	2	B173F4	1.9	5.1
B17469	17	B17470	18	5.7
B16W50	14	B16VY7	15	6.9
B16767	0.3(J)	B16771	0.3(J)	N/A
B16JX1	2(J)	B16JX2	1.7(J)	N/A
B16X03	18	B16X02	18	0.0
B15T18	16(J)	B15T17	20(J)	N/A
B167P1	16.1	B167P2	15.1	6.4
Trichloroethene (µg/L)				
B169T3	2.1	B169T1	2	4.9
B173F4	0.97(J)	B173F8	1.1	N/A
B17469	2.6	B17470	2.7	3.8
B16W50	2.4(J)	B16VY7	2.6(J)	N/A
B16771	0.16(U)	B16767	0.16(U)	N/A
B16JX2	0.16(U)	B16JX1	0.16(U)	N/A
B16X02	3(J)	B16X03	3(J)	N/A
B15T18	50(U)	B15T17	50(U)	N/A
B167P1	7.2	B167P2	7.4	2.7

Table G-2. Quality Control Results for 200-ZP-1 Operable Unit Sampling. (3 sheets)

Sample Number	Value	Sample Number	Value	RPD (%)
Field Offsite Laboratory Splits				
Field		**Laboratory**		
Carbon Tetrachloride (µg/L)				
B150C4	2,100(D)	B15M23	1,973	N/A
B13NJ3	2,400	B15T20	1,900	23.3
B15RL3	2,900	B167P0	1,974	38.0
B15RM9	5,100	B16X01	2,800	58.2
B15RN0	3,200	B16X08	1,800	56.0
B15T21	860	B13NJ4	1,100	24.5
B15RL5	1,000	B167P3	854	15.7
B15RN3	900	B16X04	690	26.4
Chloroform (µg/L)				
B150C4	12	B15M23	12	0.0
B13NJ3	20	B15T20	14(J)	N/A
B15RM8	14	B16X00	12	15.4
B15RL3	12	B167P0	9.9	19.2
B16X01	26	B15RM9	24	8.0
B13NJ2	16	B15T19	13(J)	N/A
B15RN0	17	B16X08	16	6.1
B13NJ4	20	B15T21	17	16.2
B15RL5	21	B167P3	20.2(J)	N/A
B16X04	17	B15RN3	20	16.2
Trichlorethene (µg/L)				
B15M23	2	B150C4	2	0.0
B13NJ3	4.7	B15T20	50	165.6
B16X00	2(J)	B15RM8	2	N/A
B167P0	2.4(J)	B15RL3	2.2	N/A
B16X01	7	B15RM9	12	52.6
B15RN0	10	B16X08	6	50.0
B13NJ4	3.5	B15T21	50	173.8
B15RL5	3.1	B167P3	2.5	21.4
B16X04	2(J)	B15RN3	2	N/A
B13NJ2	9.4	B15T19	50(U)	N/A

(D) = diluted
(J) = estimated
(U) = undetected
N/A = not applicable
RPD = relative percent difference

Table G-3. Available Holding Time Data Received for FY03 Carbon Tetrachloride Offsite Laboratory Samples.

Sample *Identification*	Calculated RPD	Laboratory *Received Date*	Laboratory *Analysis Date*	Holding *Time*
B15T20	23.3	10/25/02	10/31/02	6
B15T21	24.1[a]	10/25/02	10/31/02	6
B16X04	26.4	05/02/03	05/12/03	10
B16X08	56.0	05/02/03	05/12/03	10
B16X01	58.2	05/02/03	05/12/03	10
B167P0	38.0	01/31/03	02/11/03	11

[a] Laboratory results are higher than field results.

APPENDIX H

TREND PLOTS FOR WELLS AT THE 200-ZP-1 OPERABLE UNIT

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CONTENTS

FIGURES

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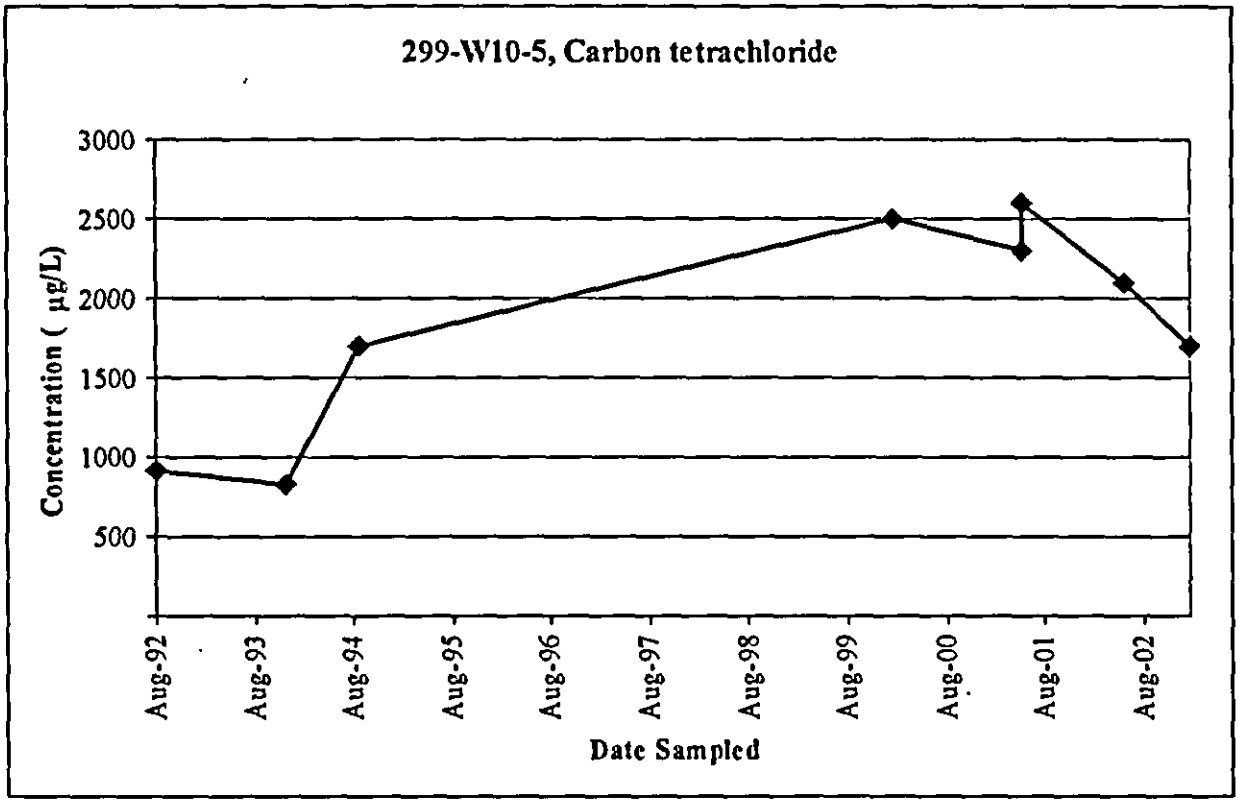
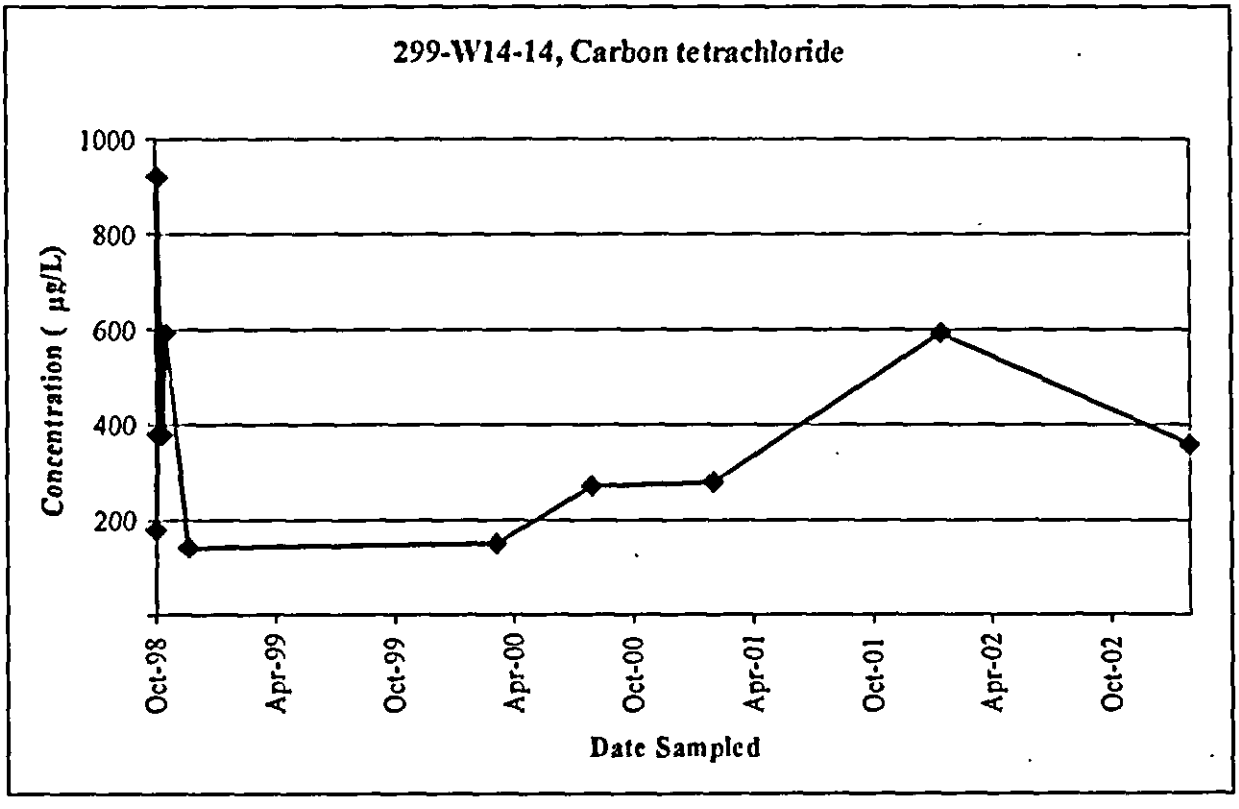
Figure H-1. 200-ZP-1 Groundwater Operable Unit, Carbon Tetrachloride Concentration Trends at Selected Monitoring Wells. (17 sheets)





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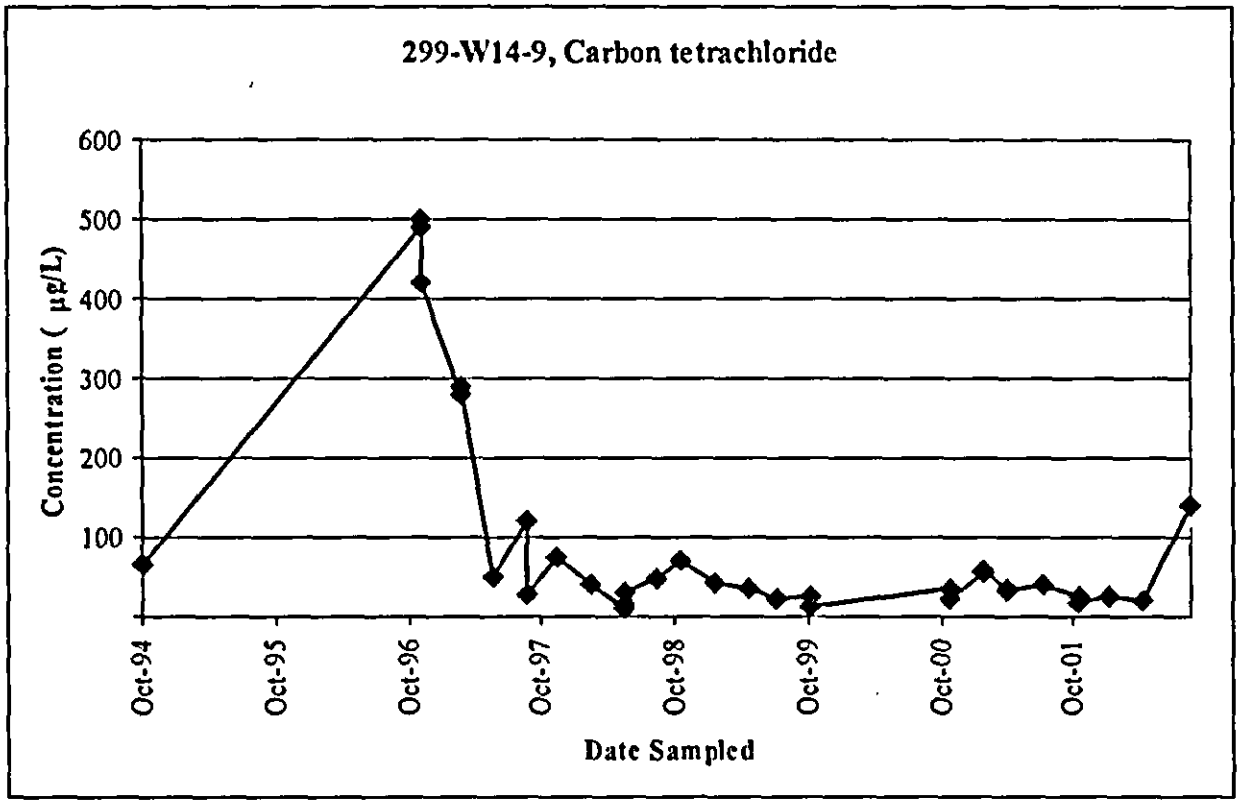

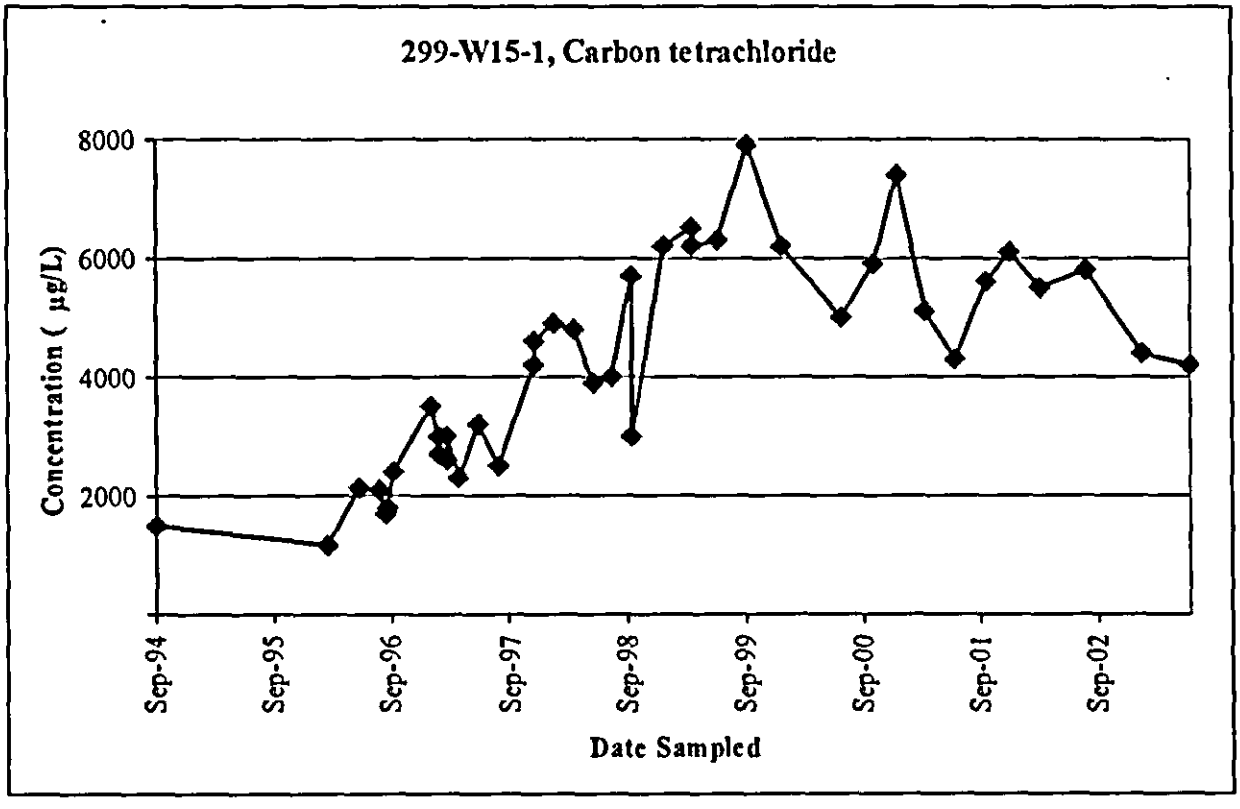

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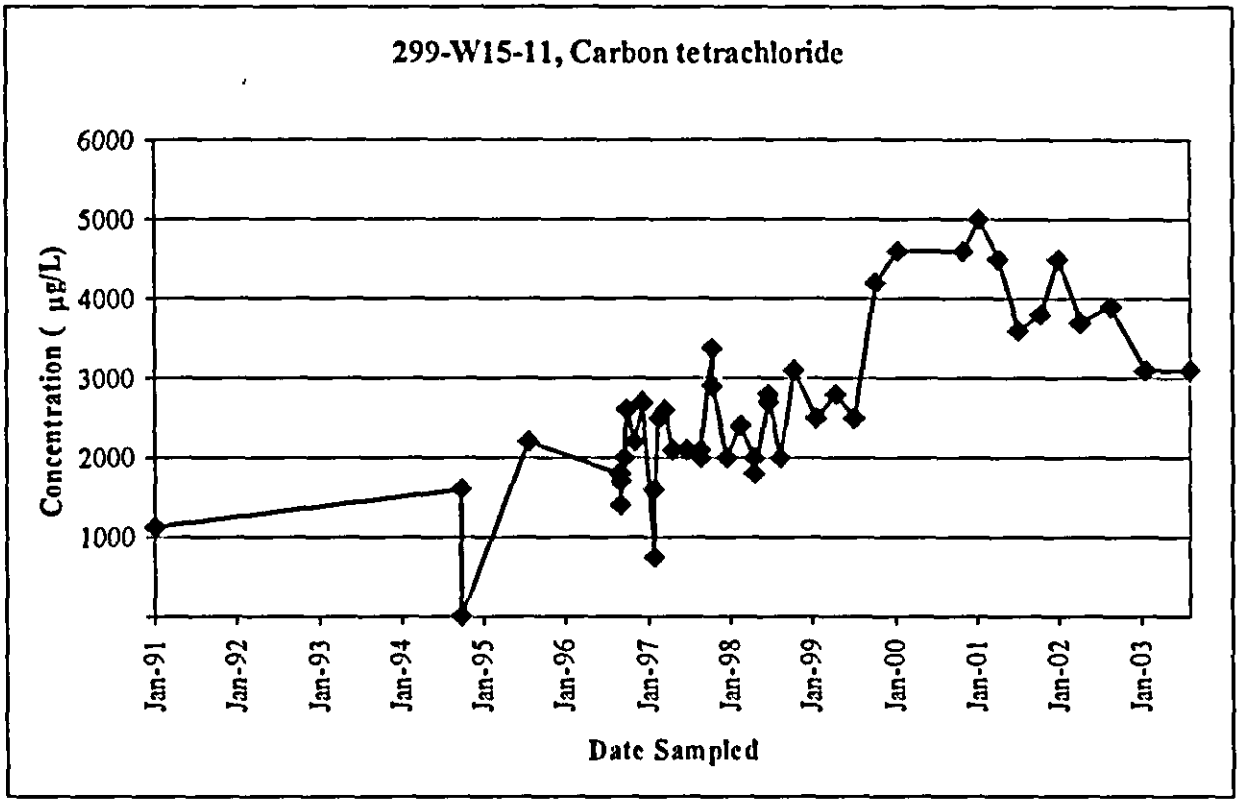

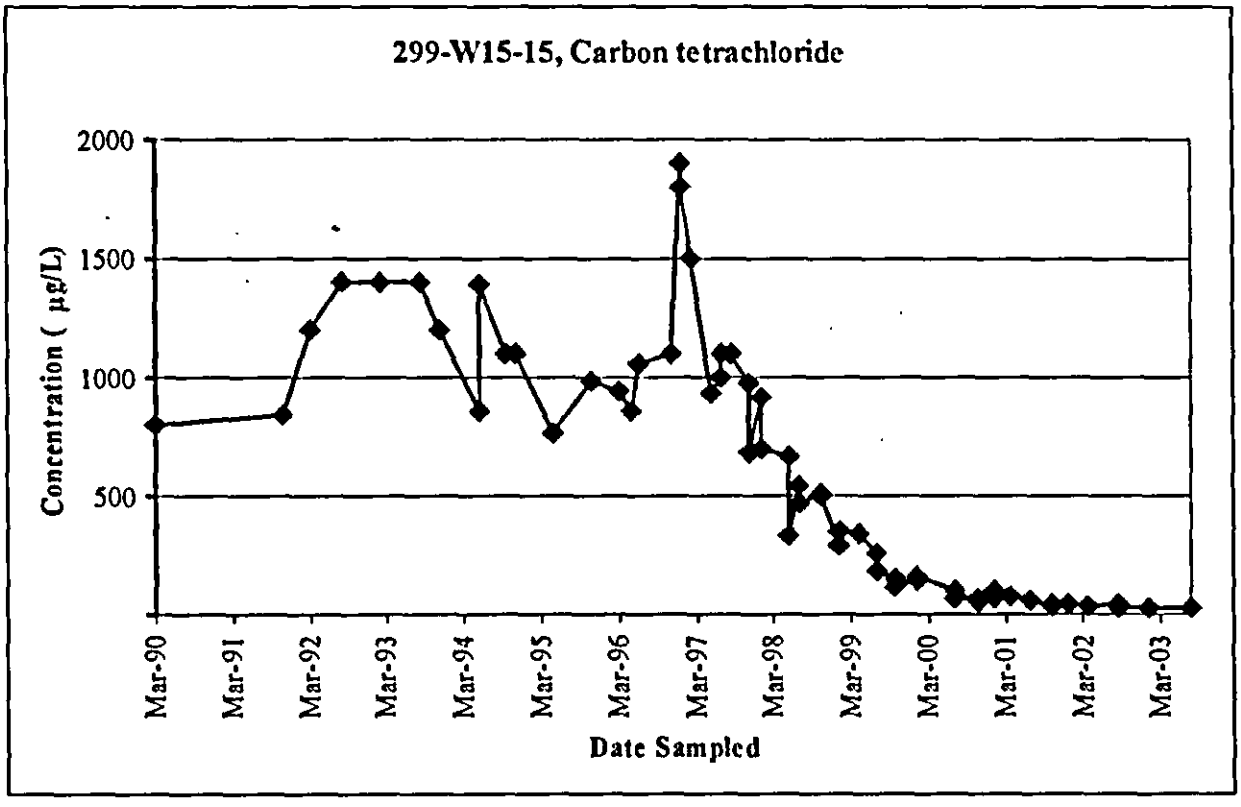

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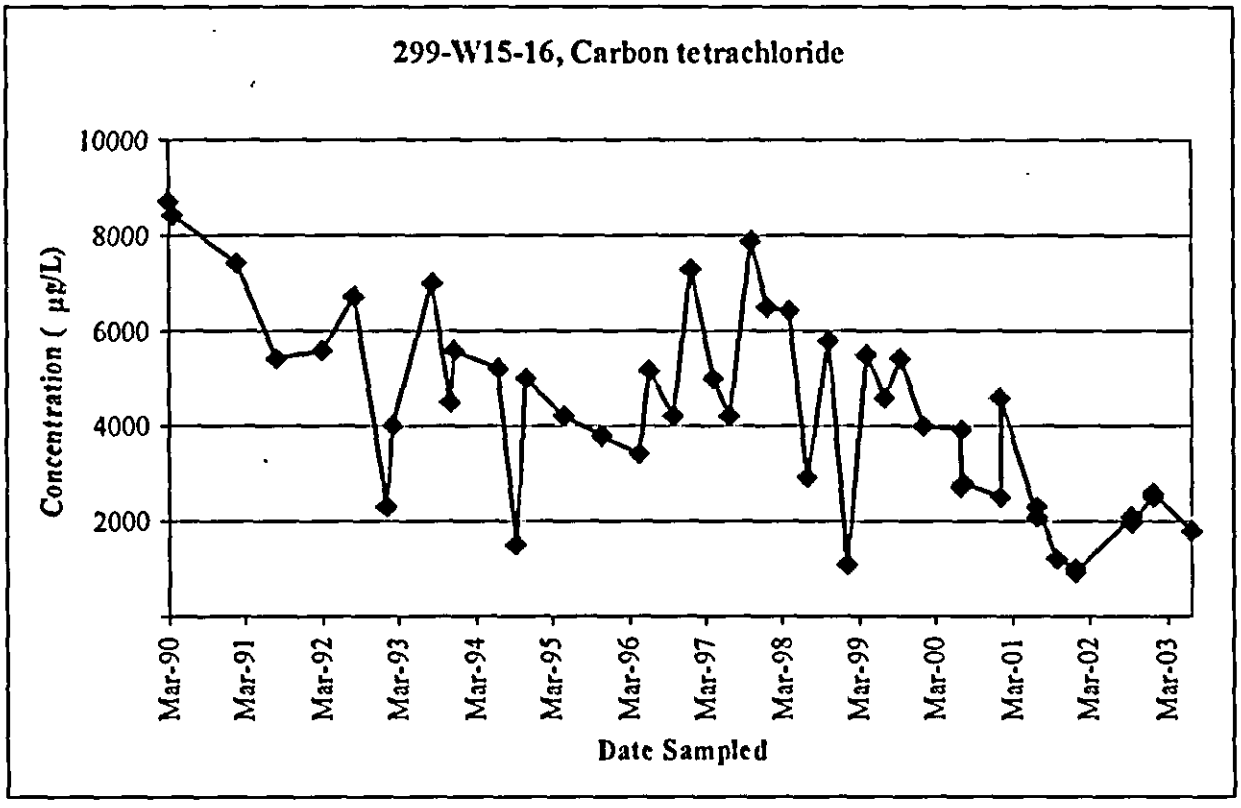

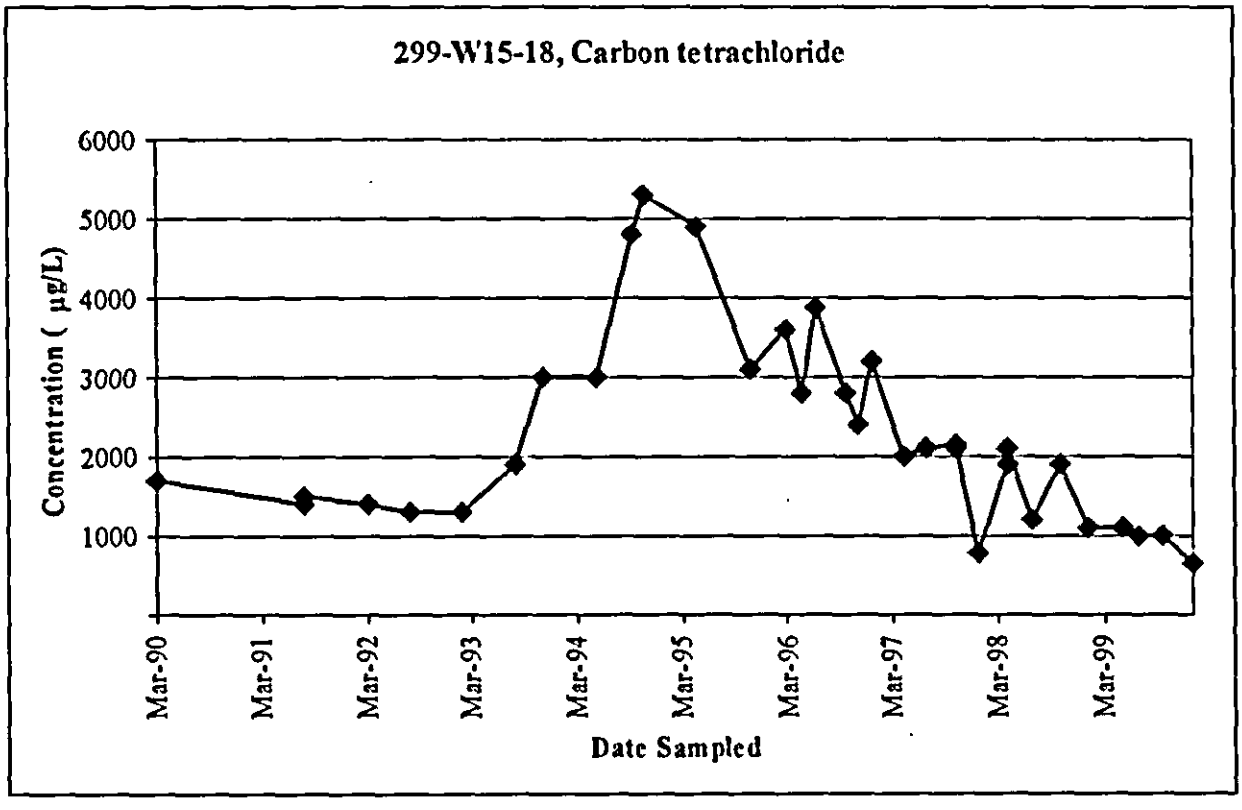

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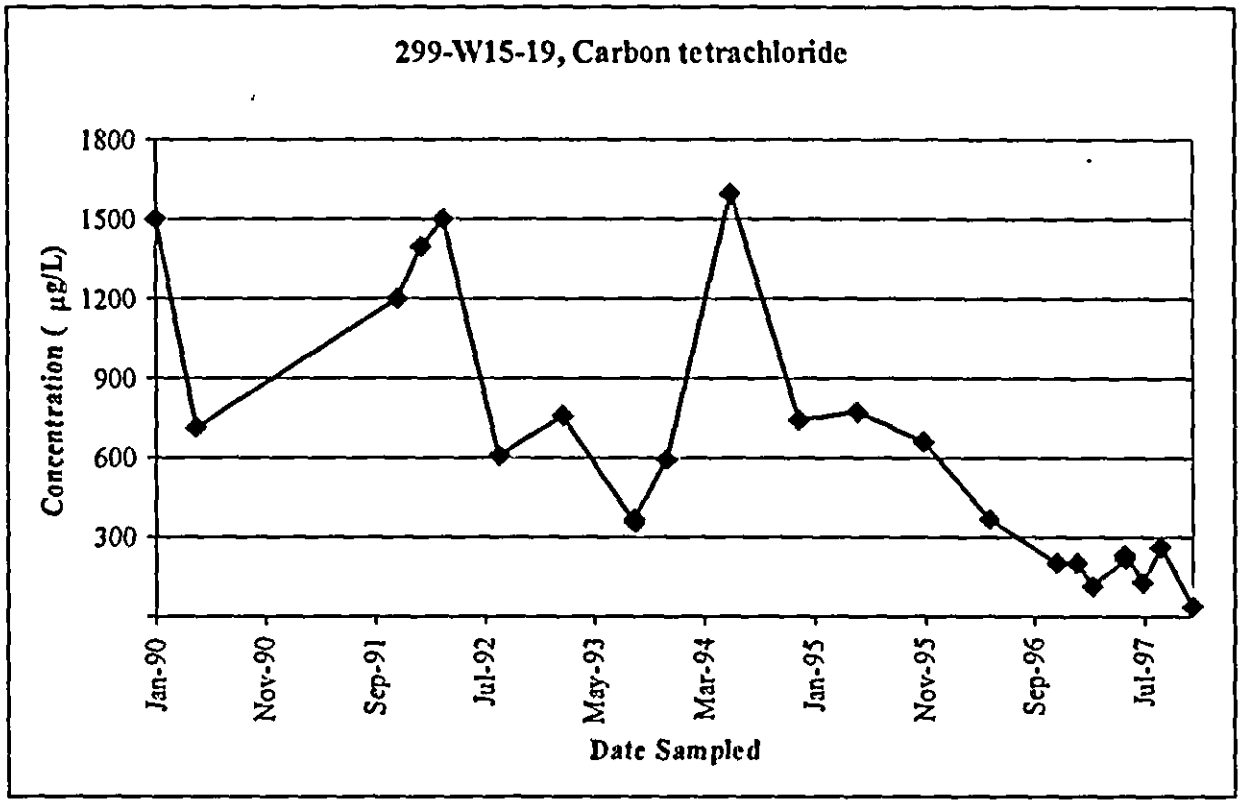

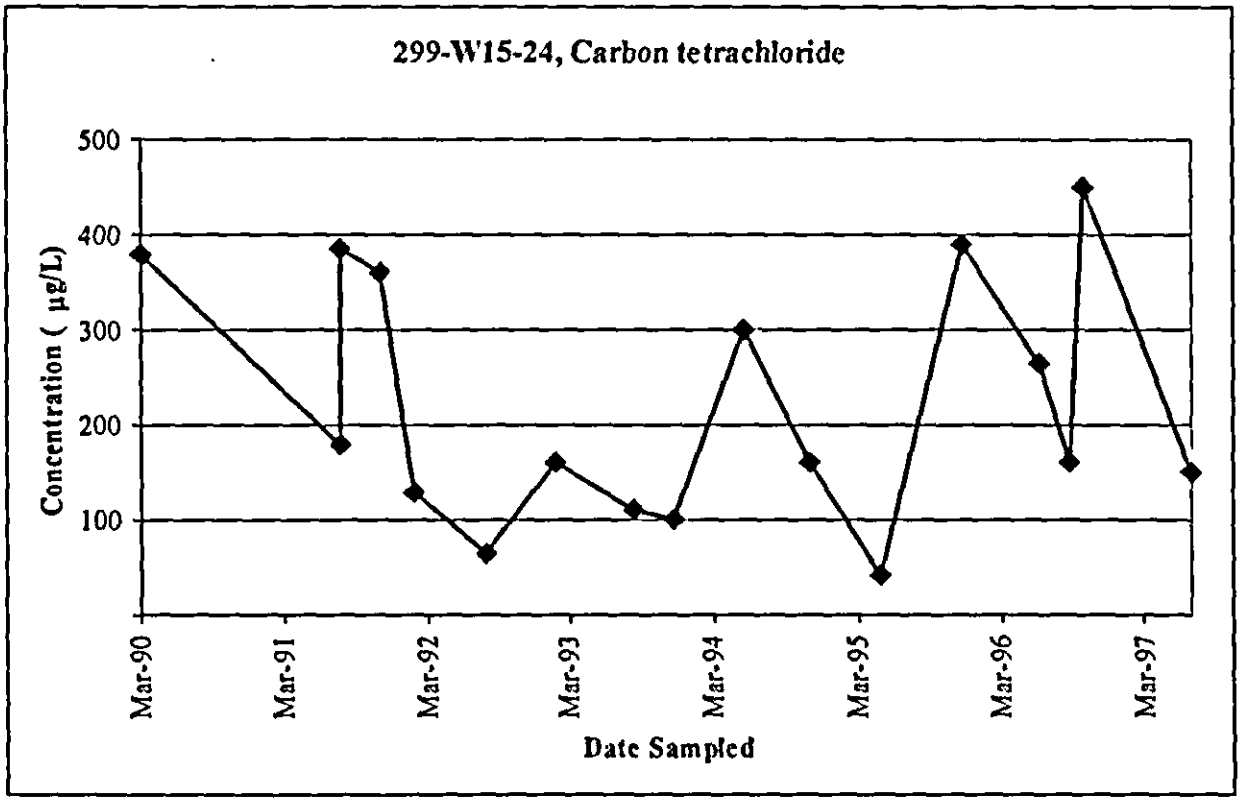

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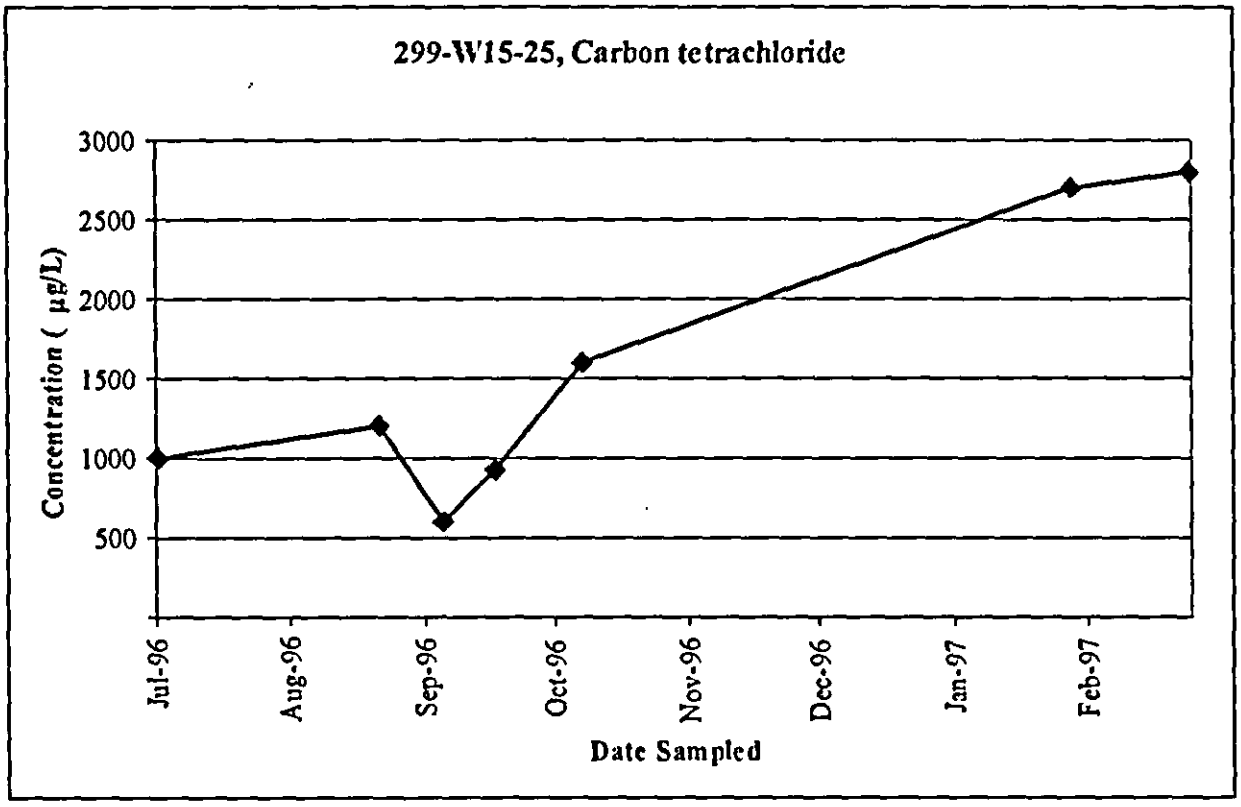

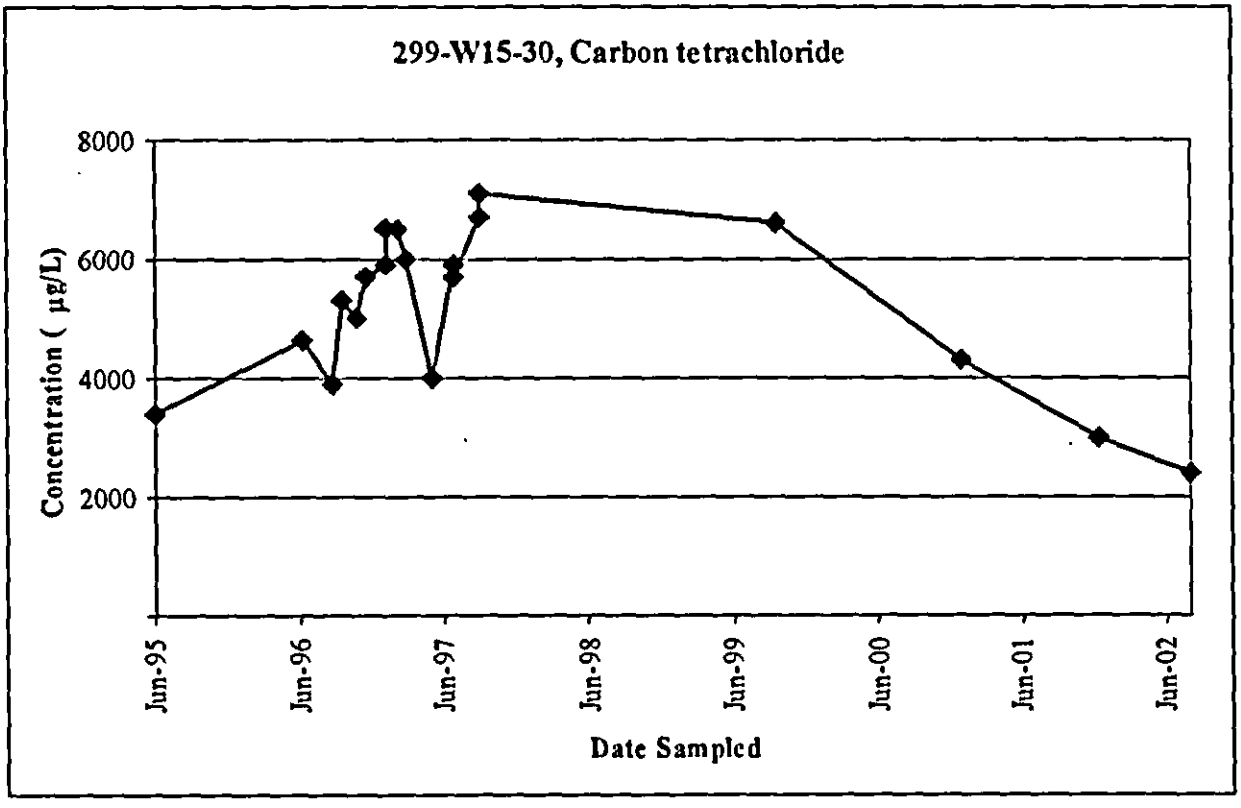

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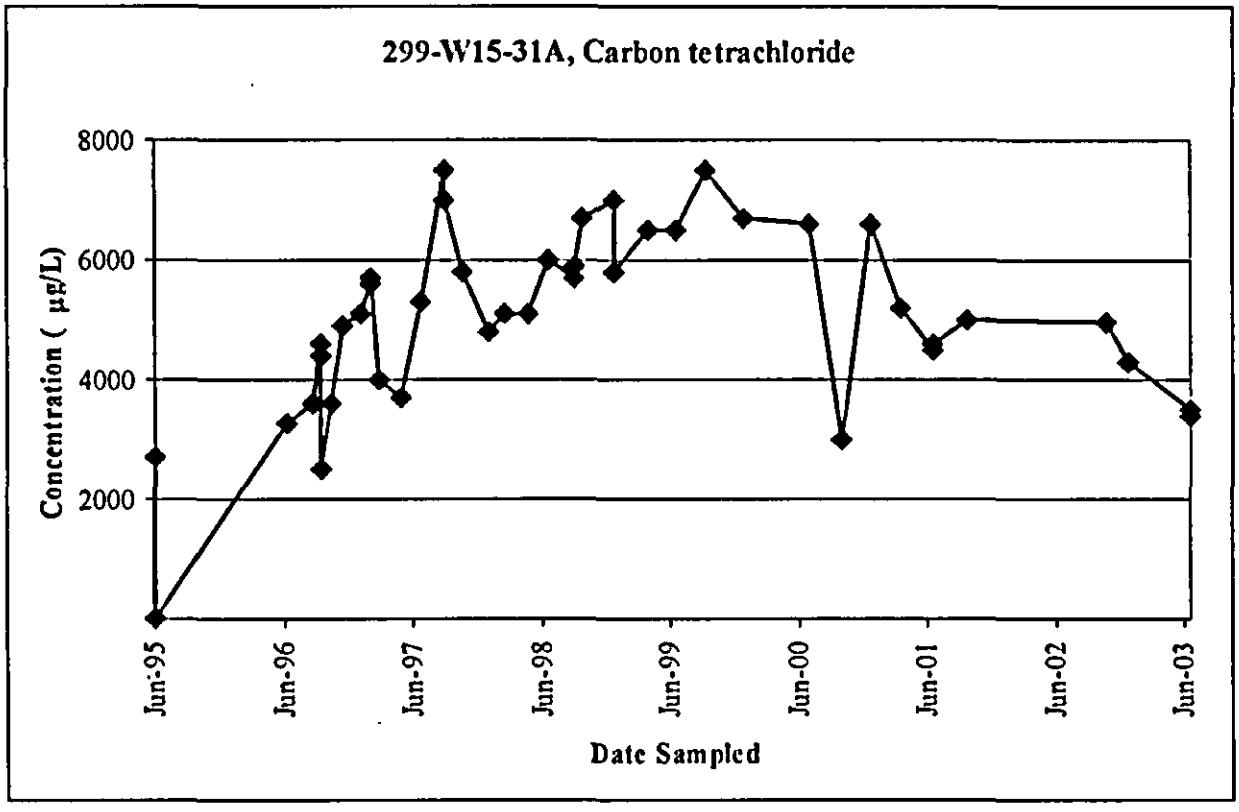

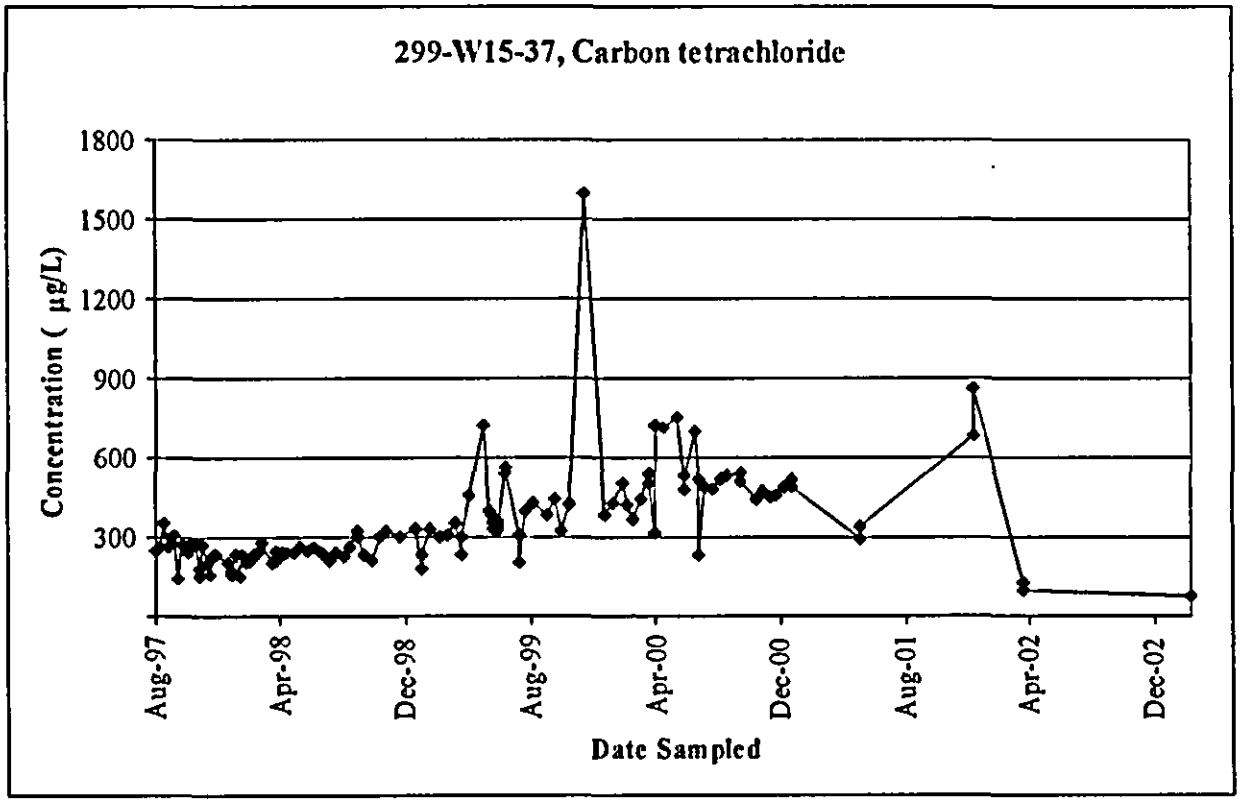

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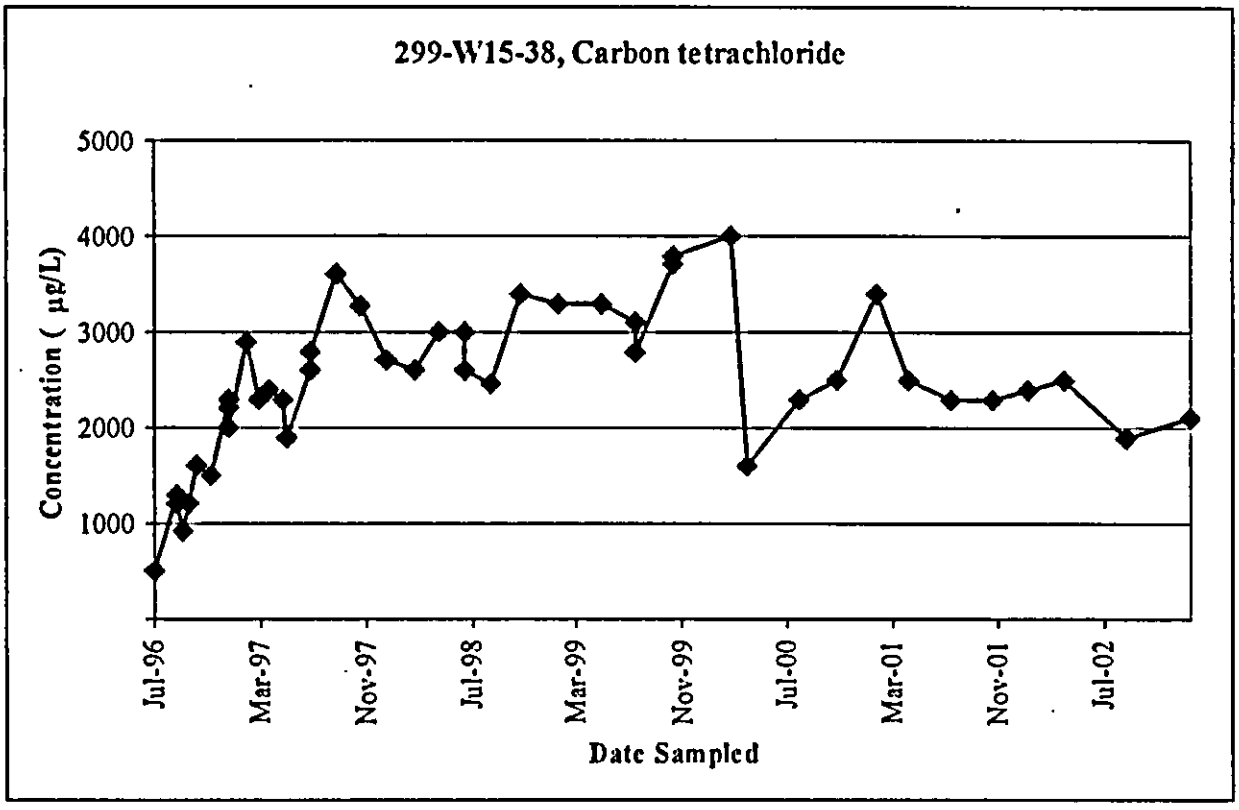

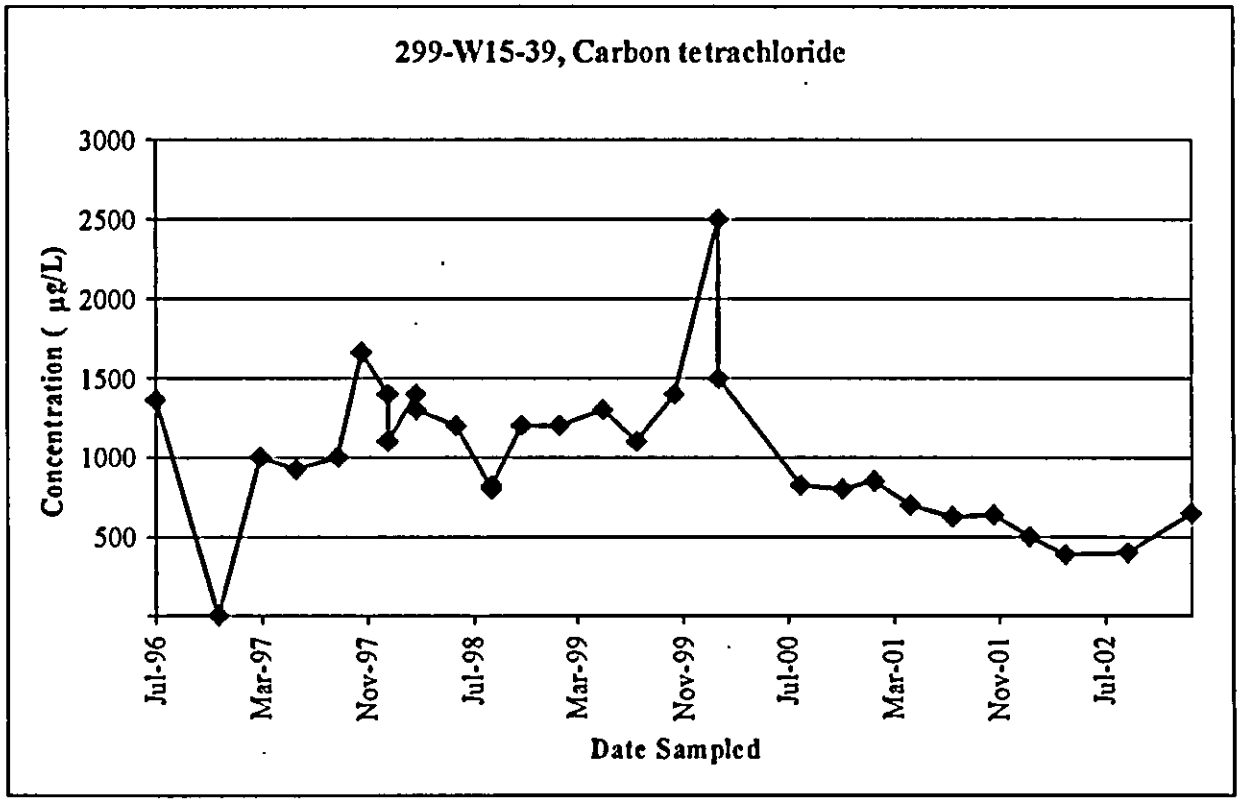

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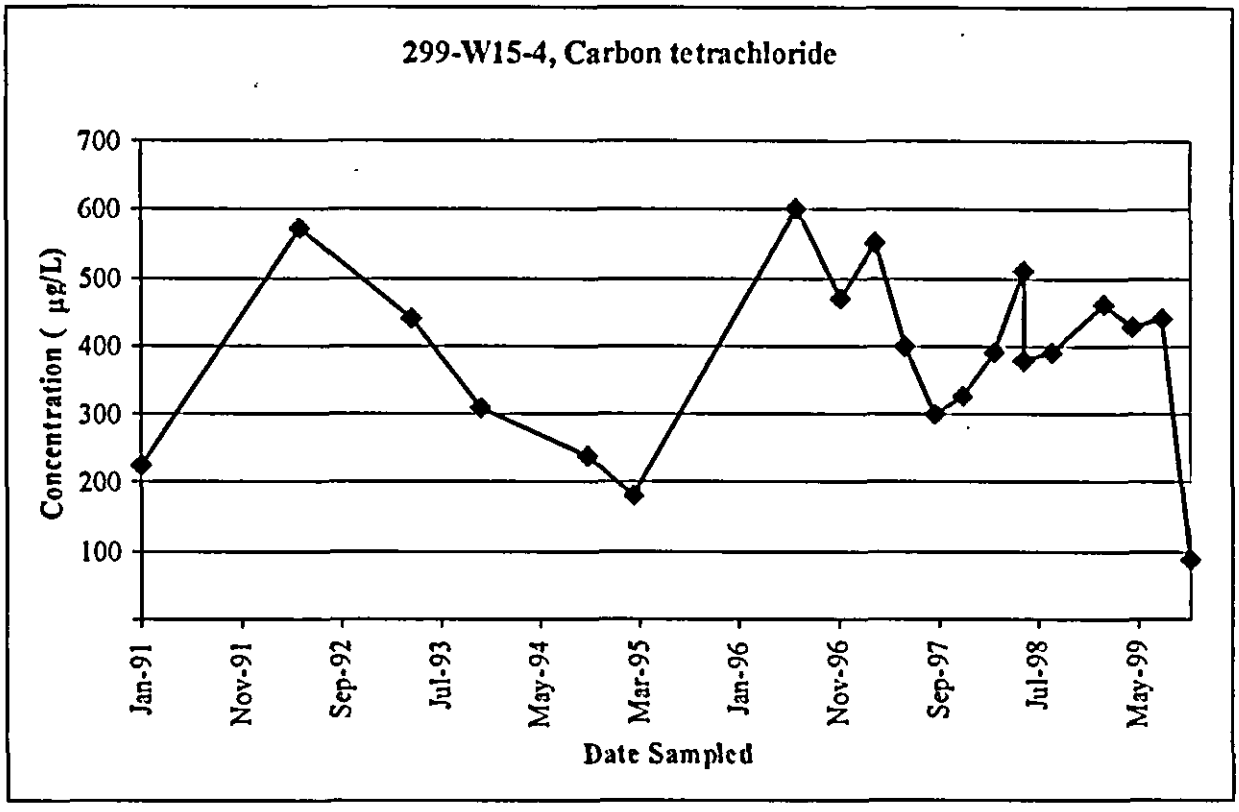

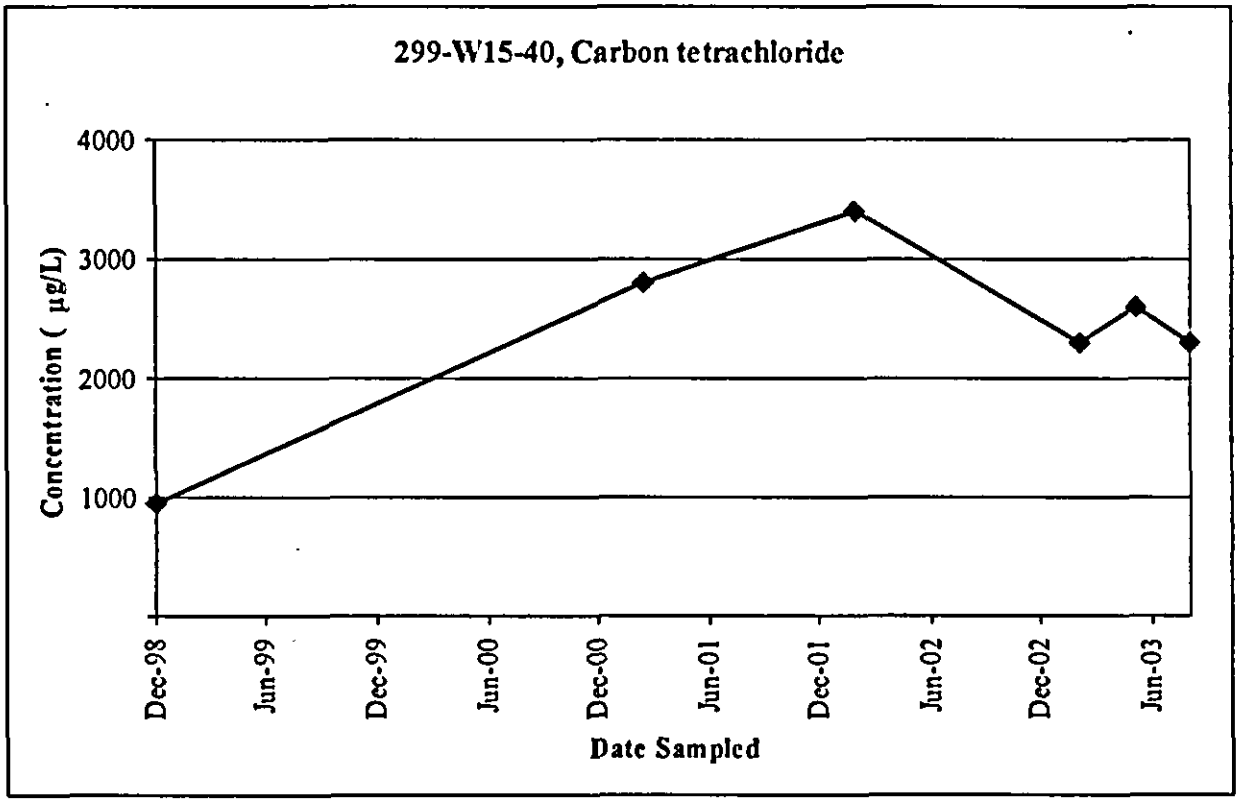

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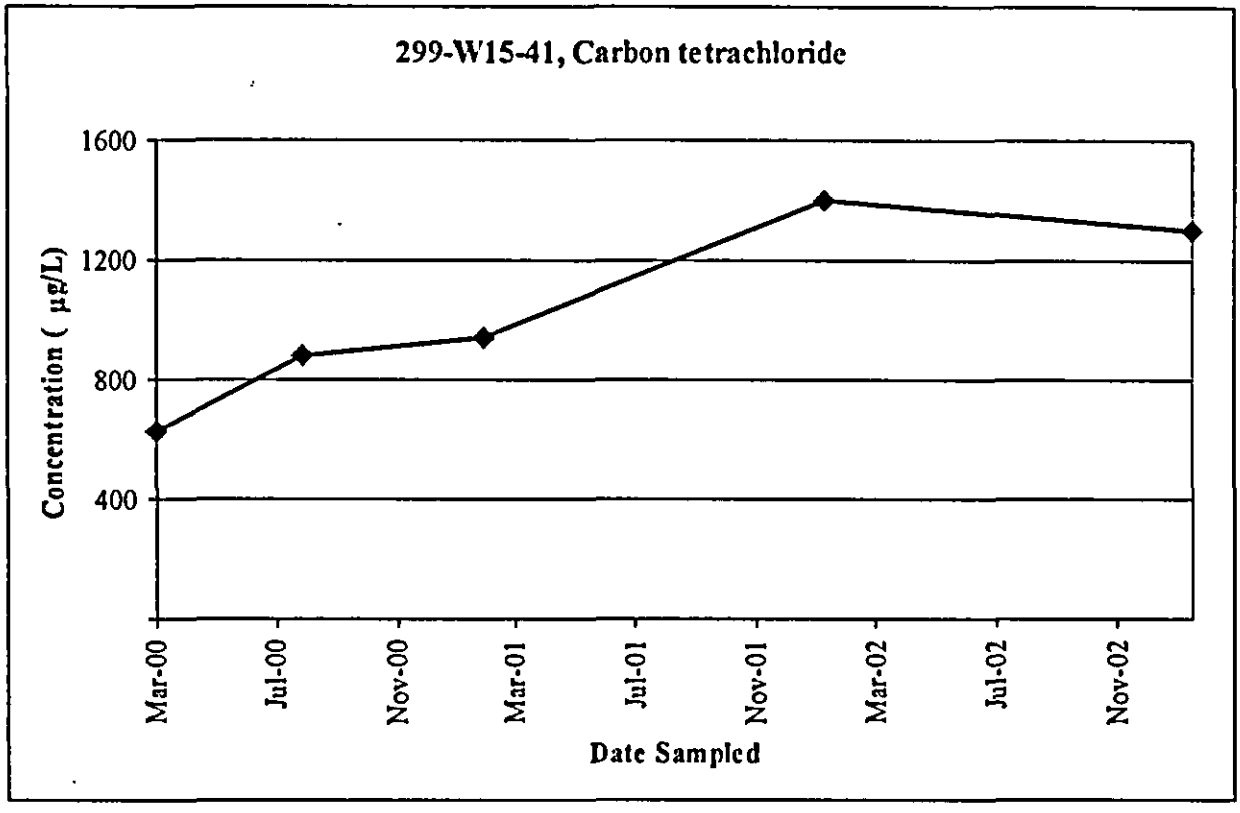

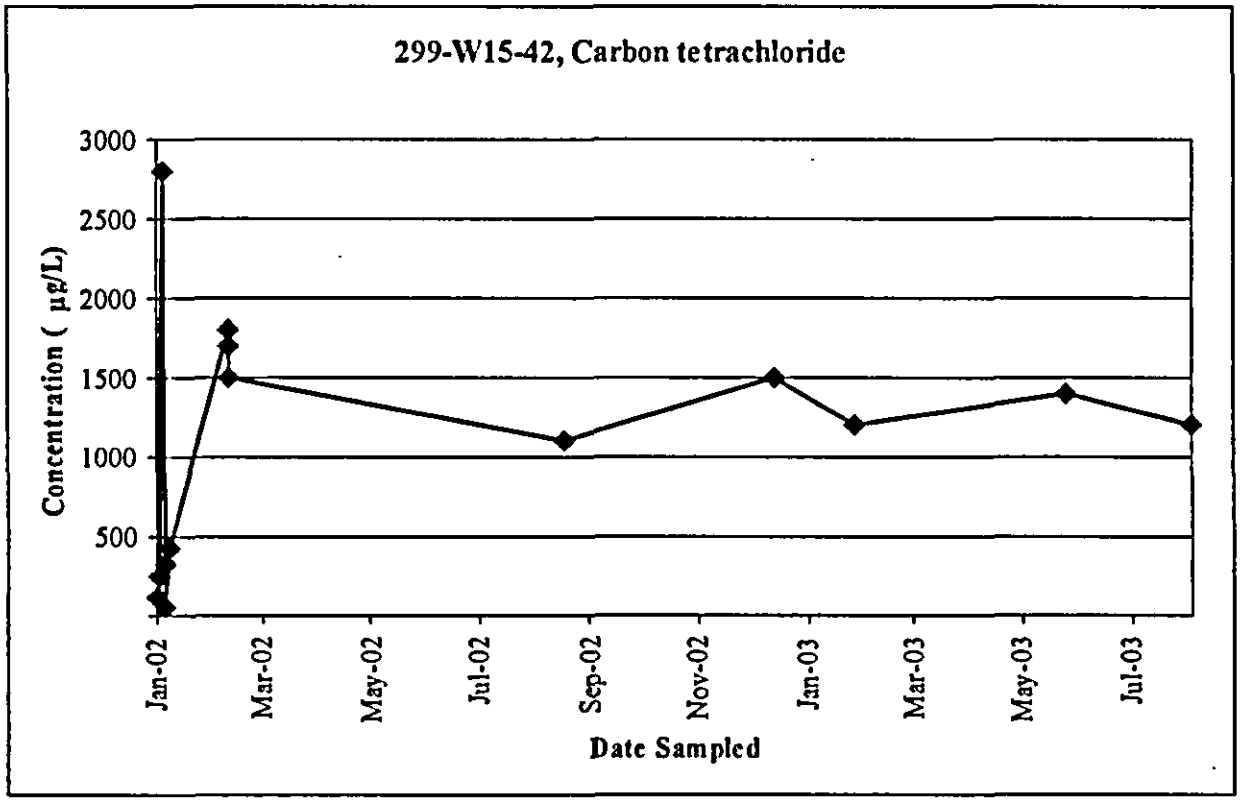

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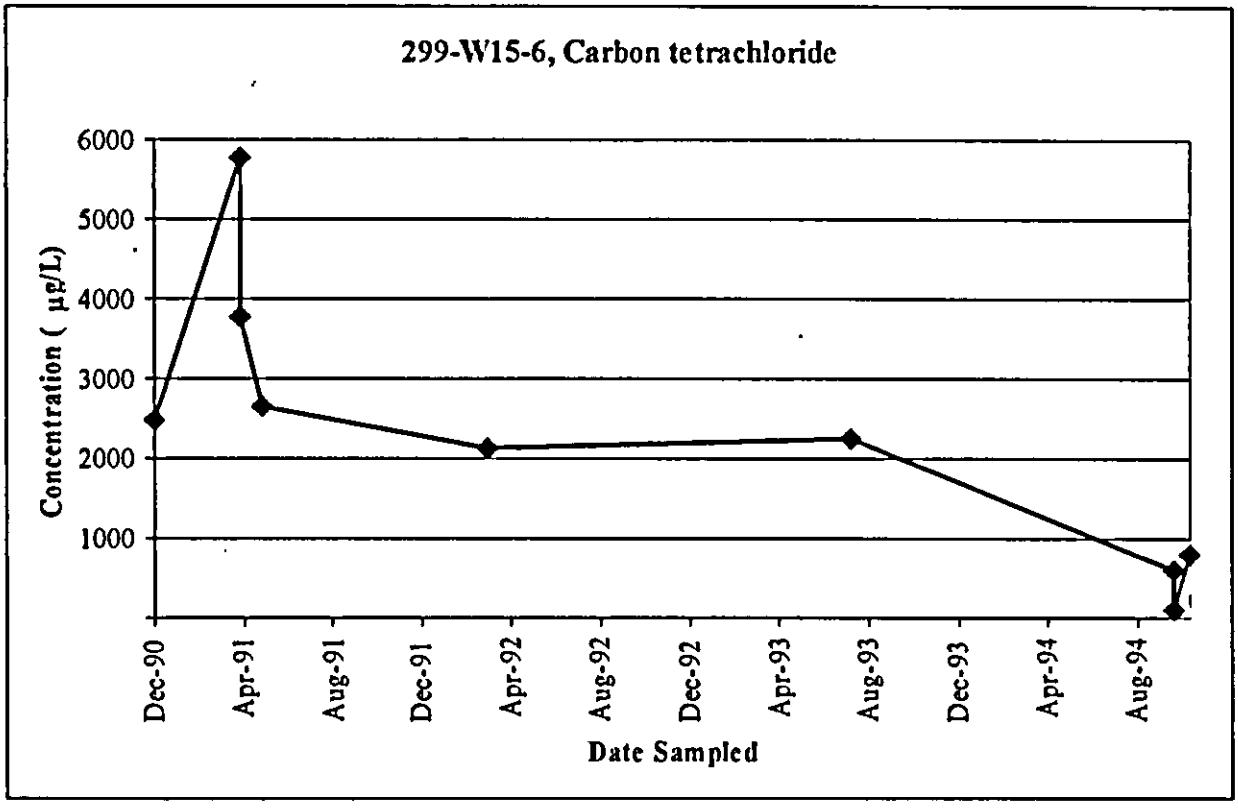

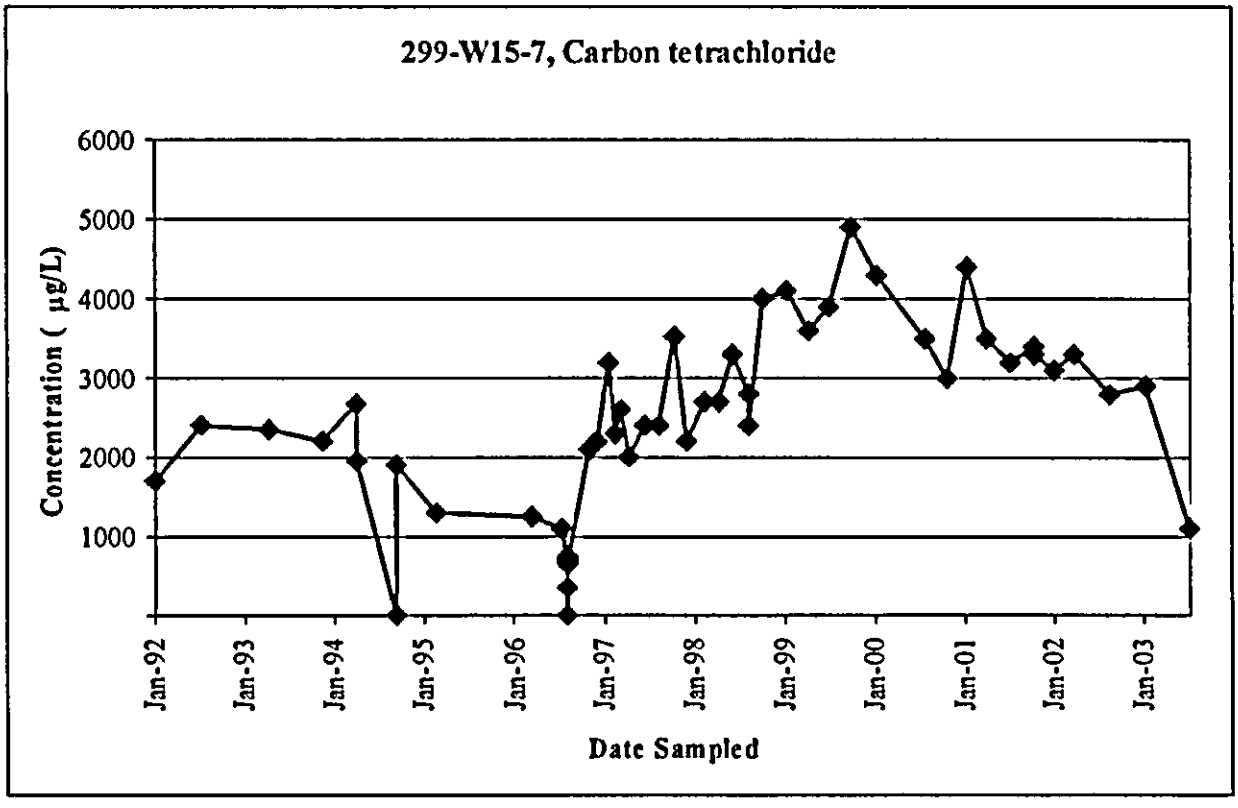

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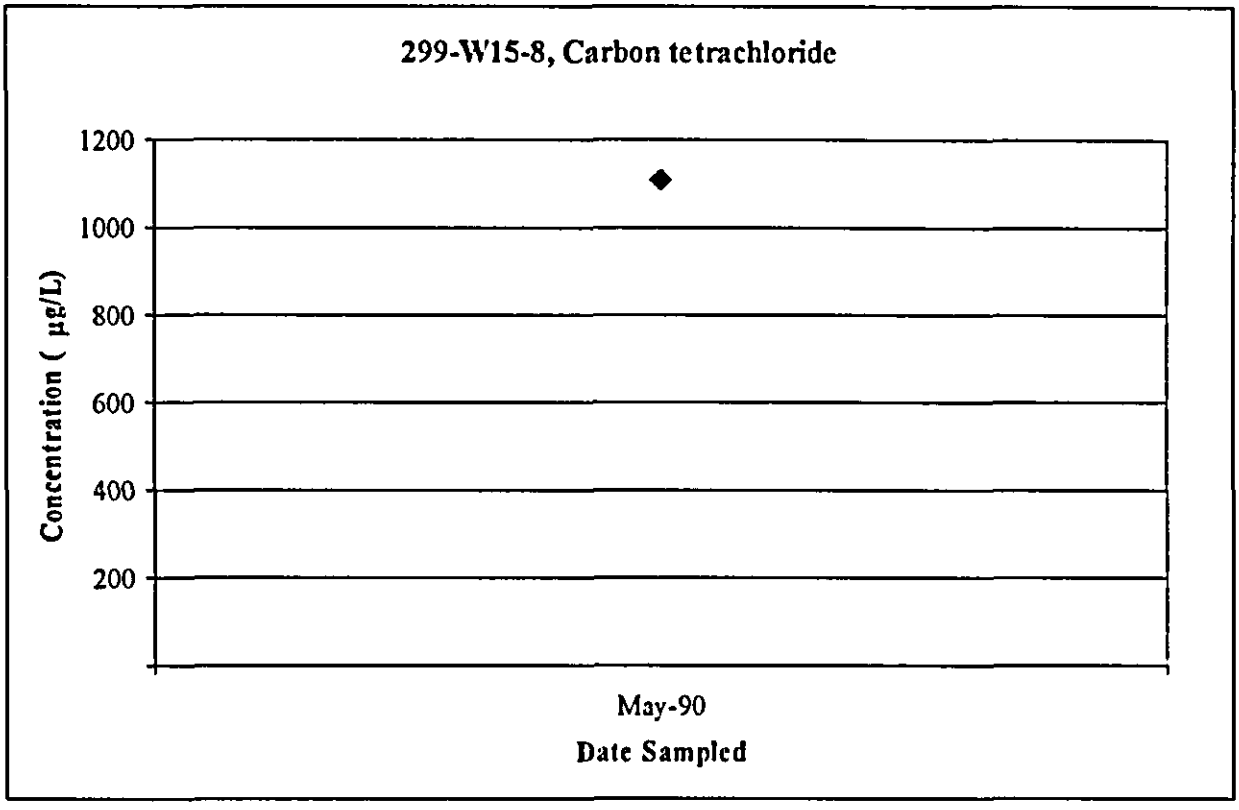

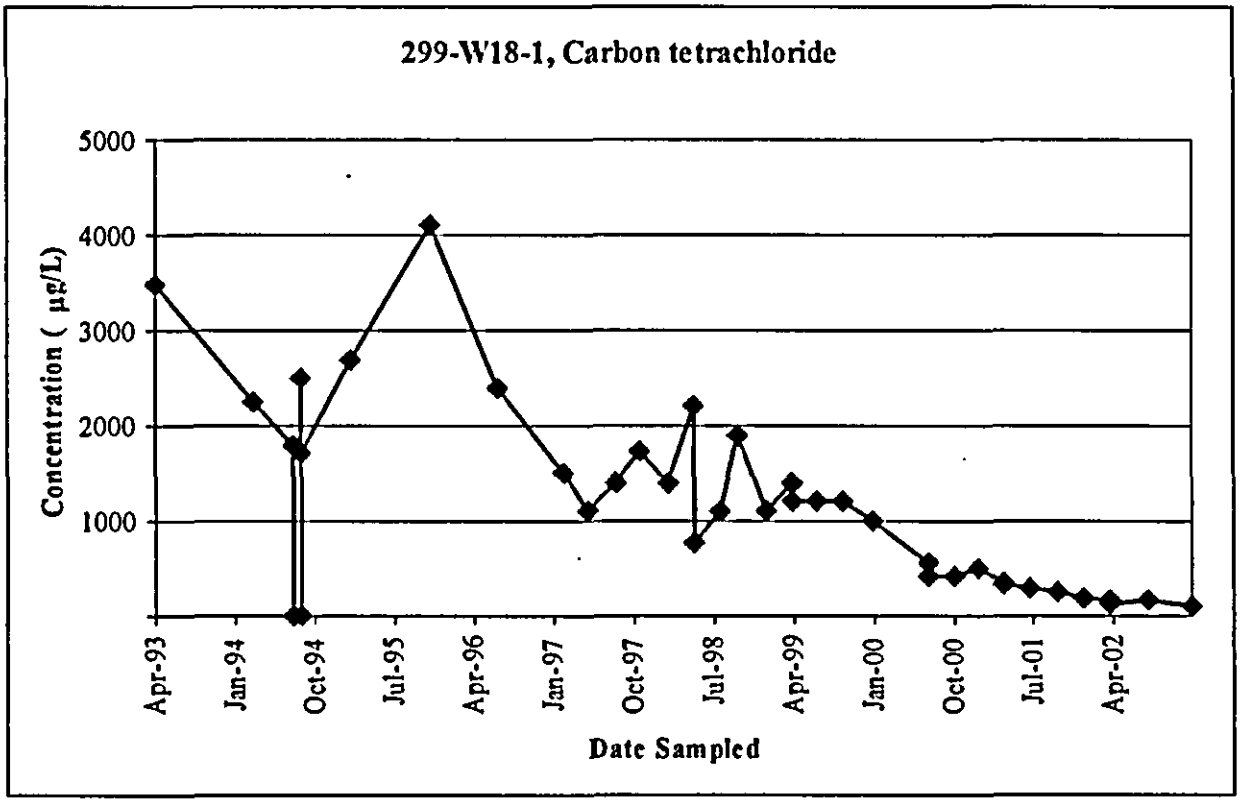

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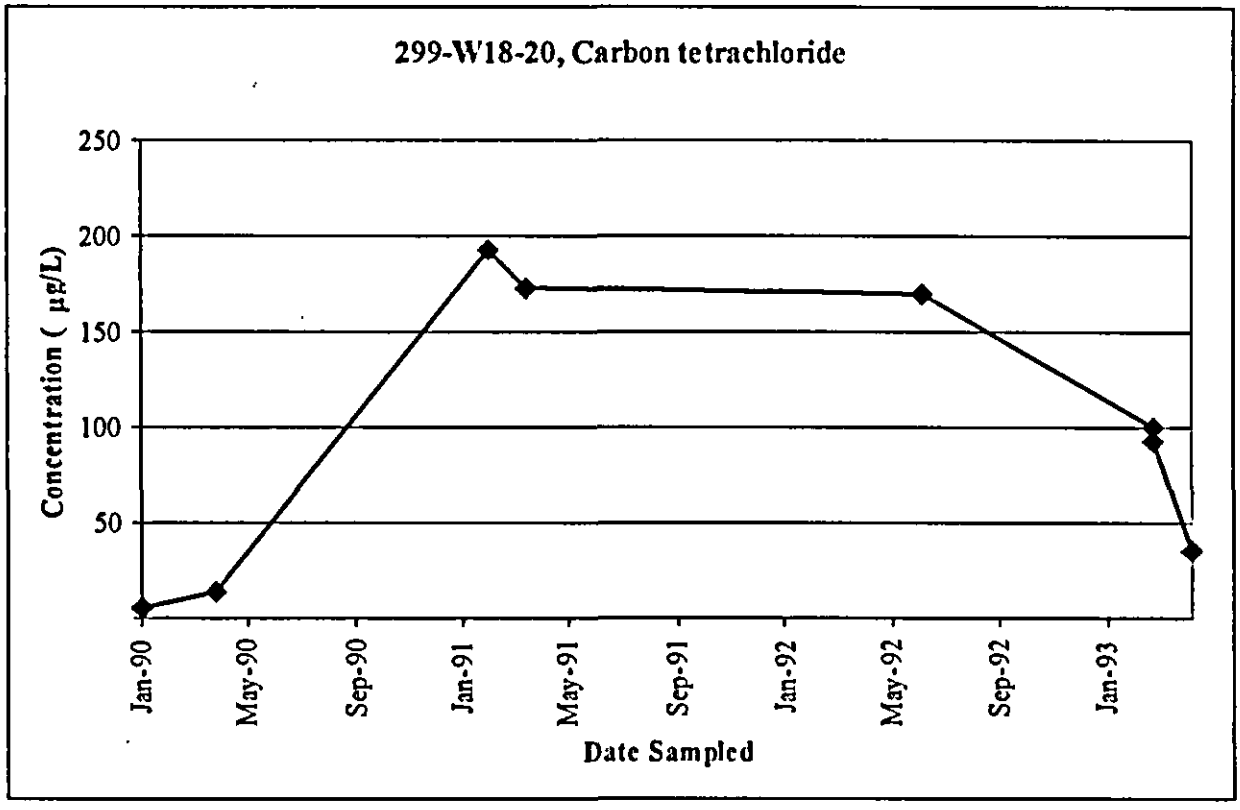

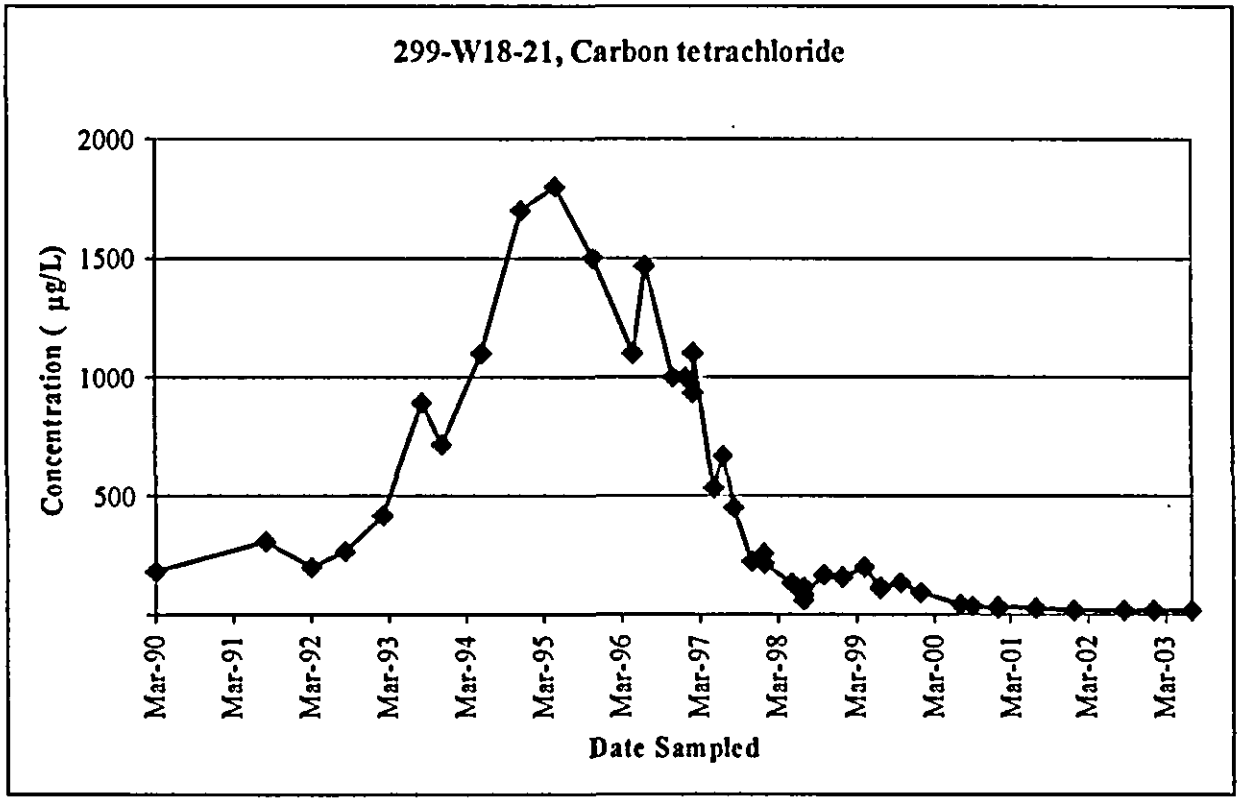

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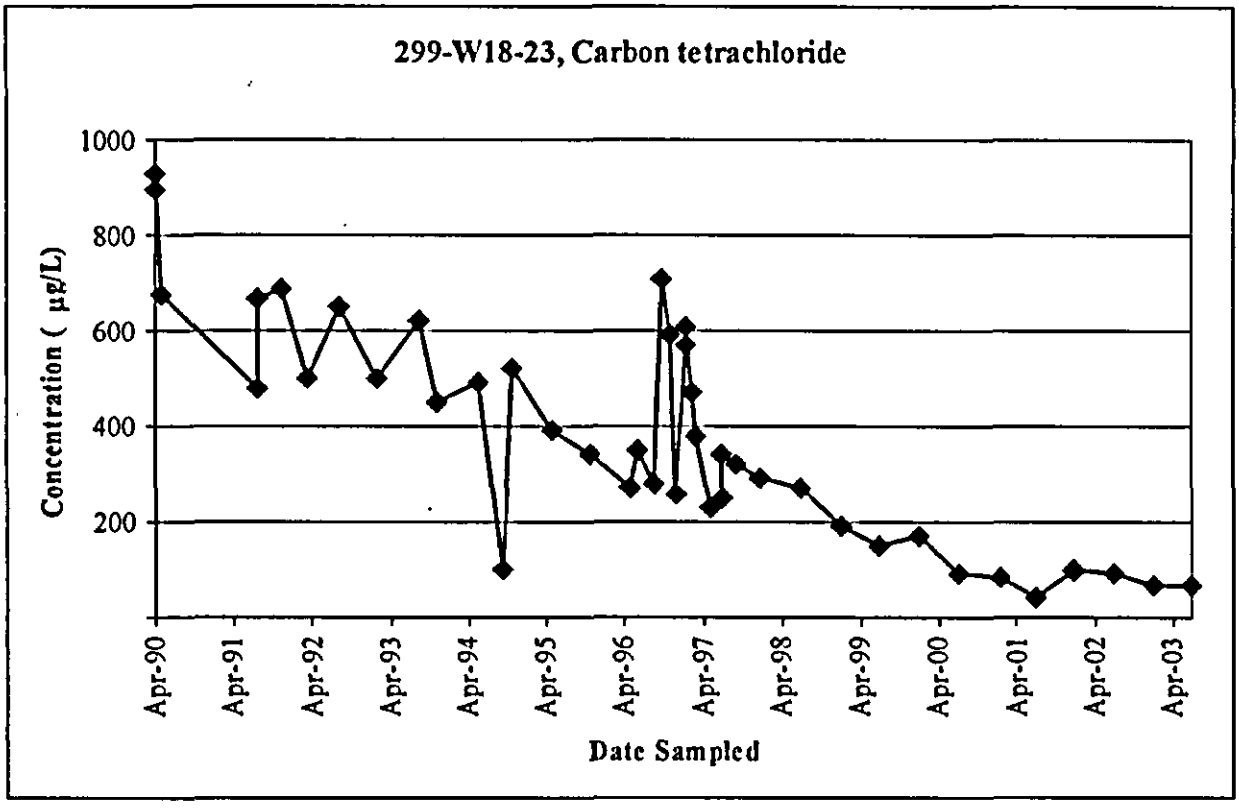

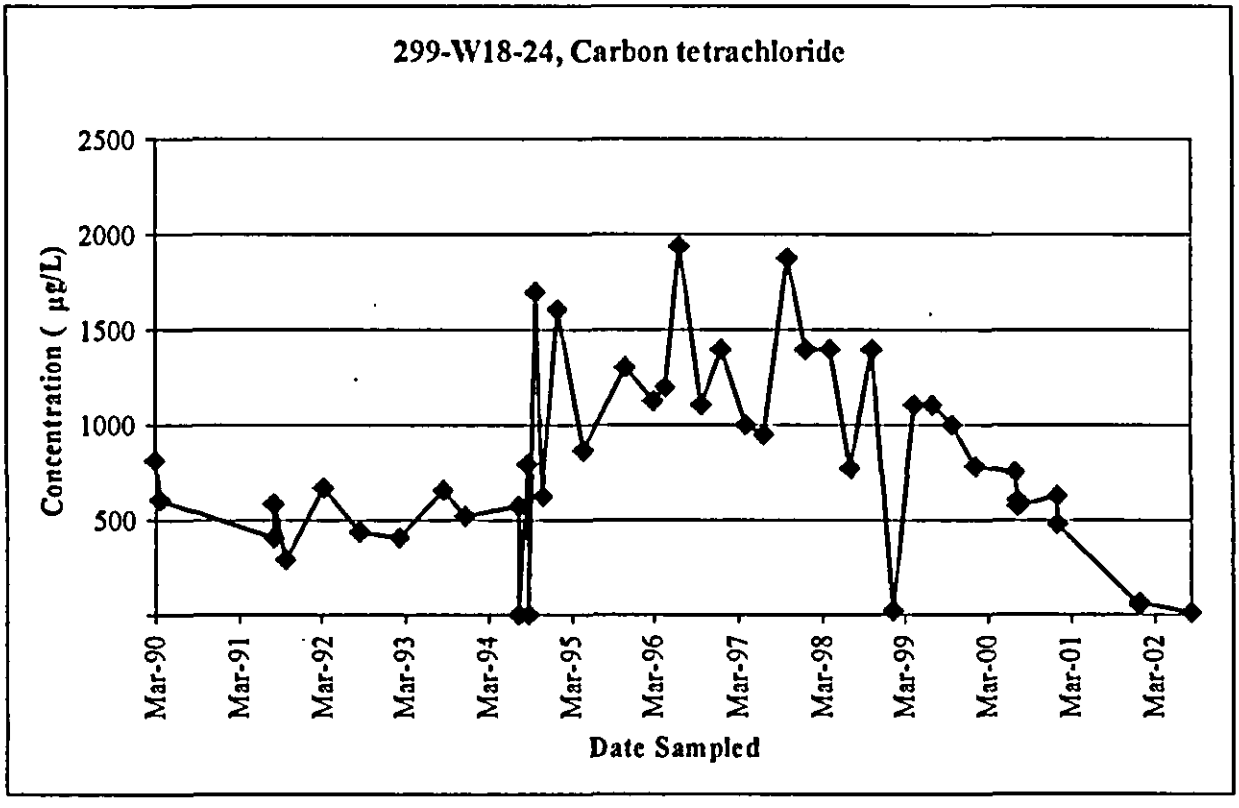

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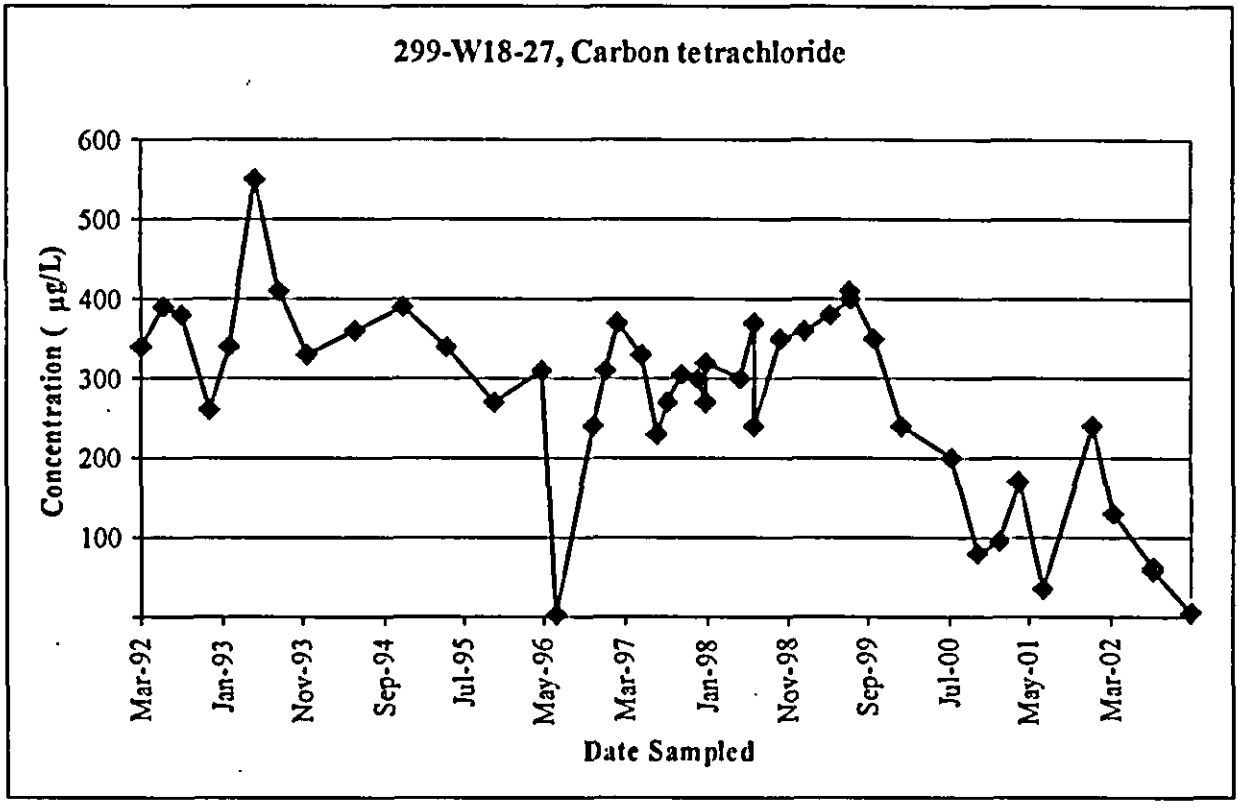

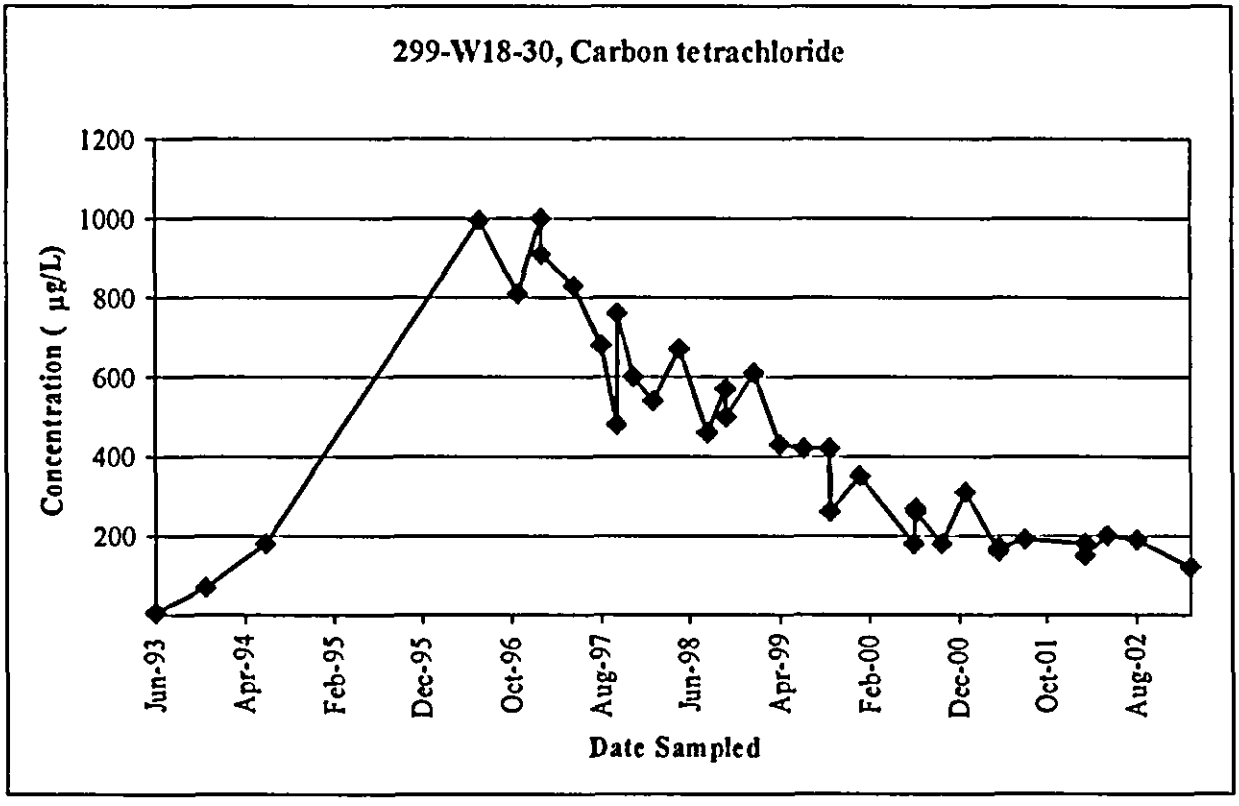

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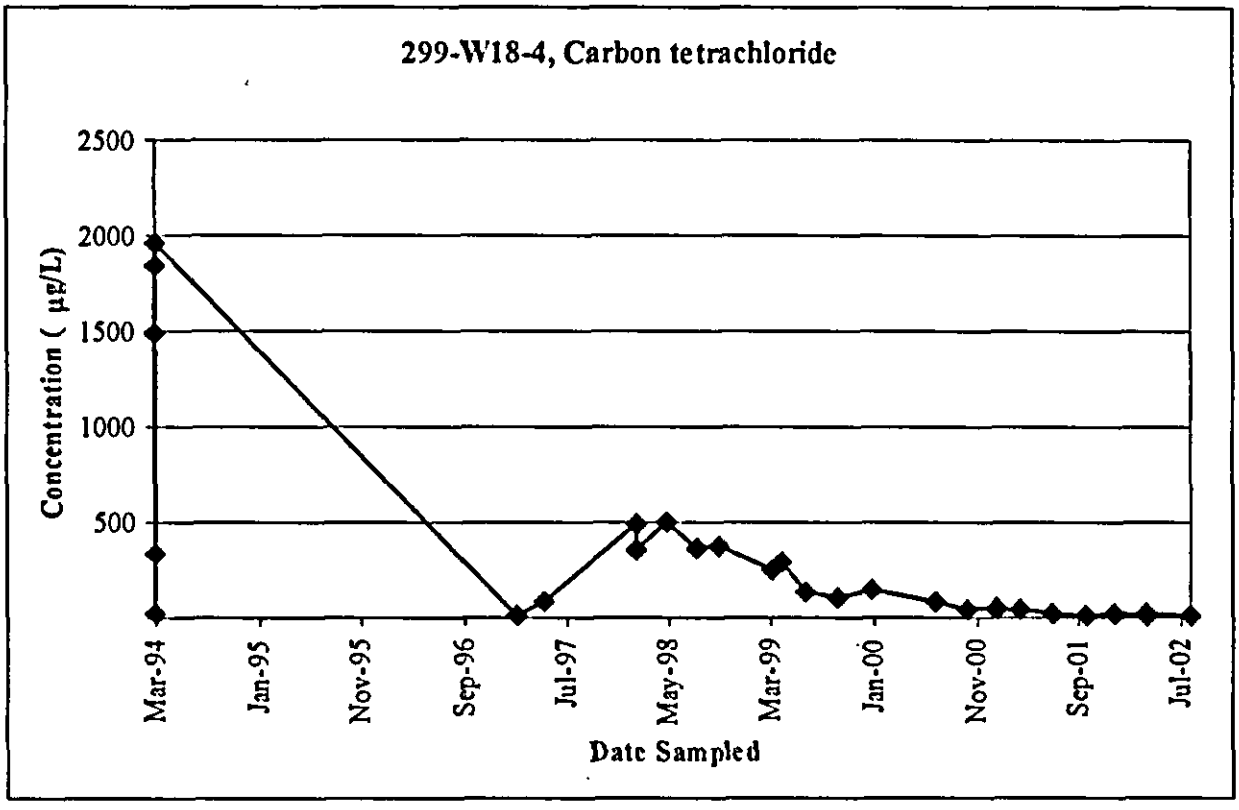

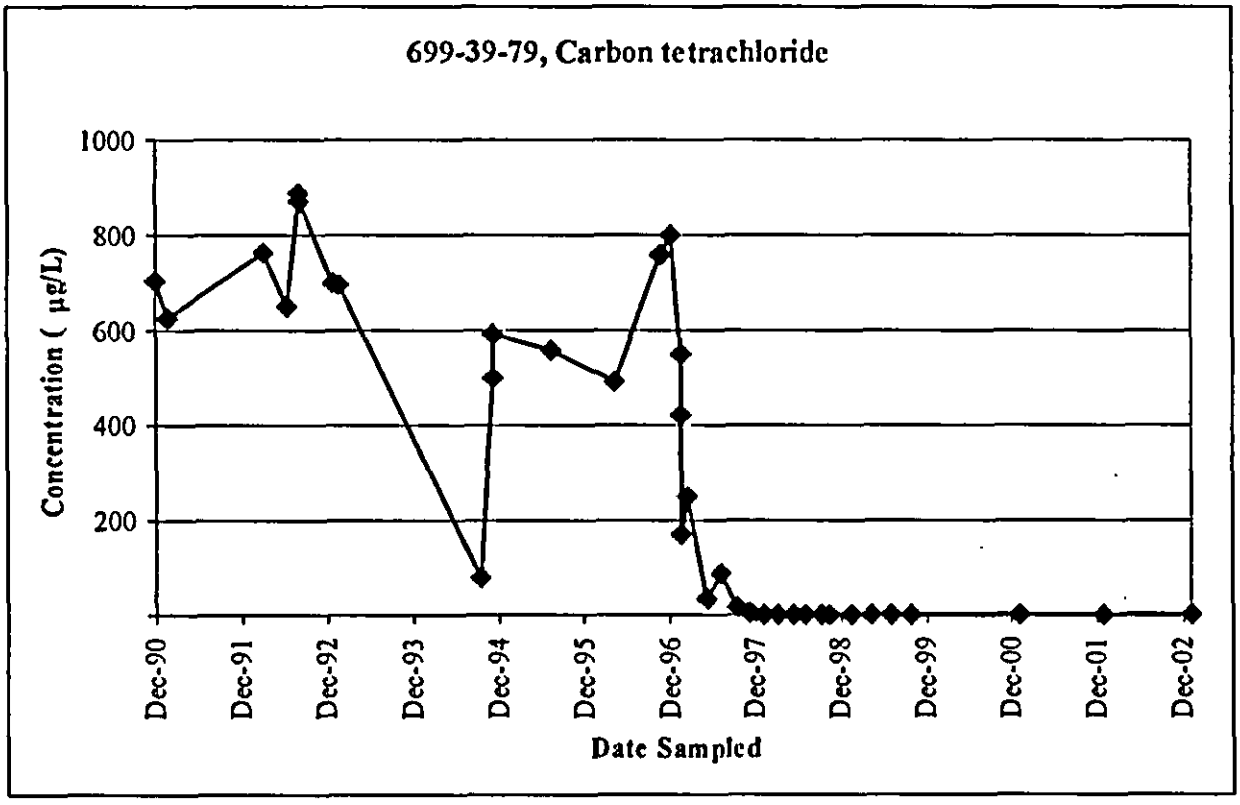

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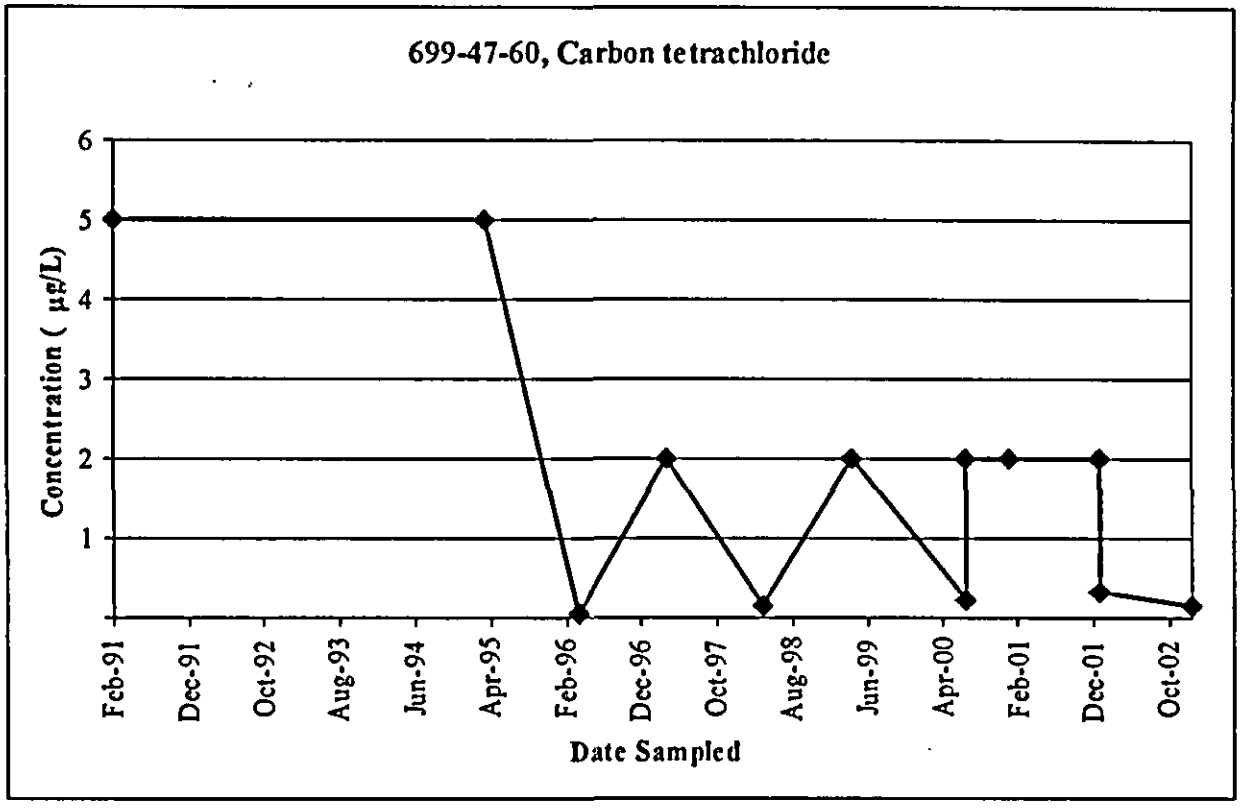

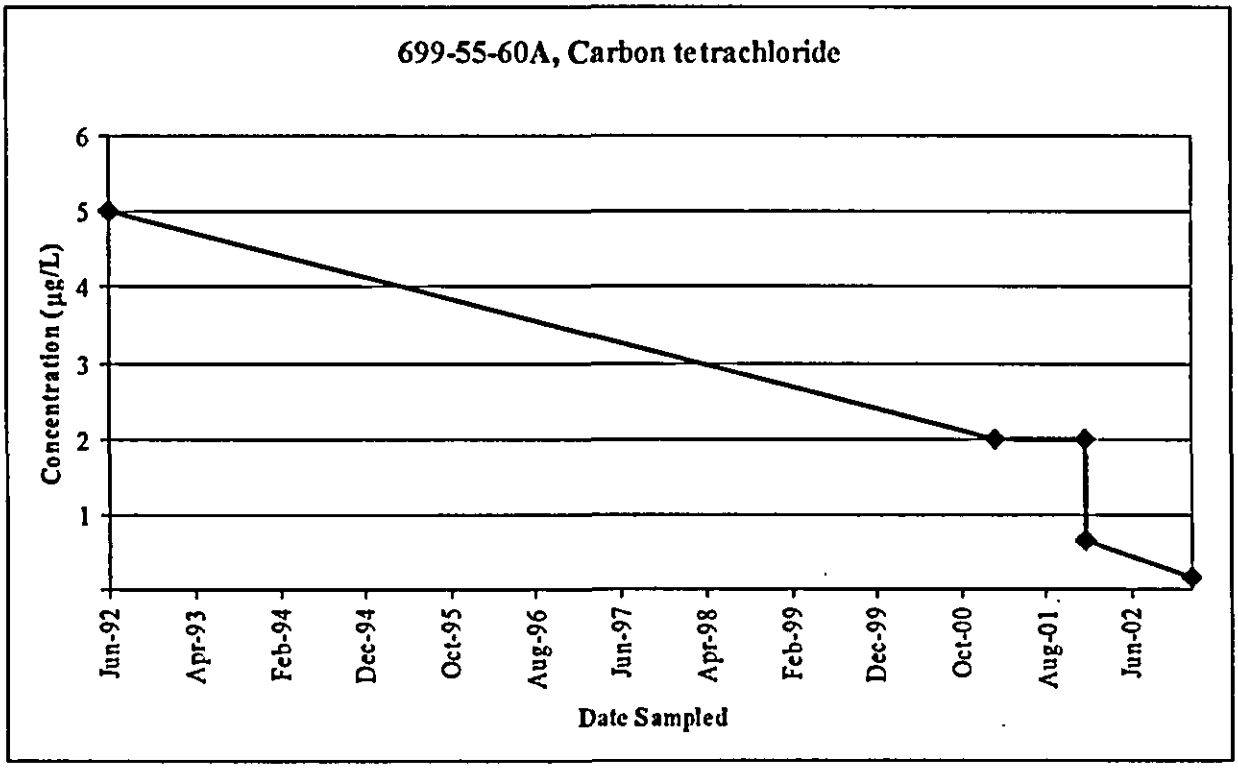

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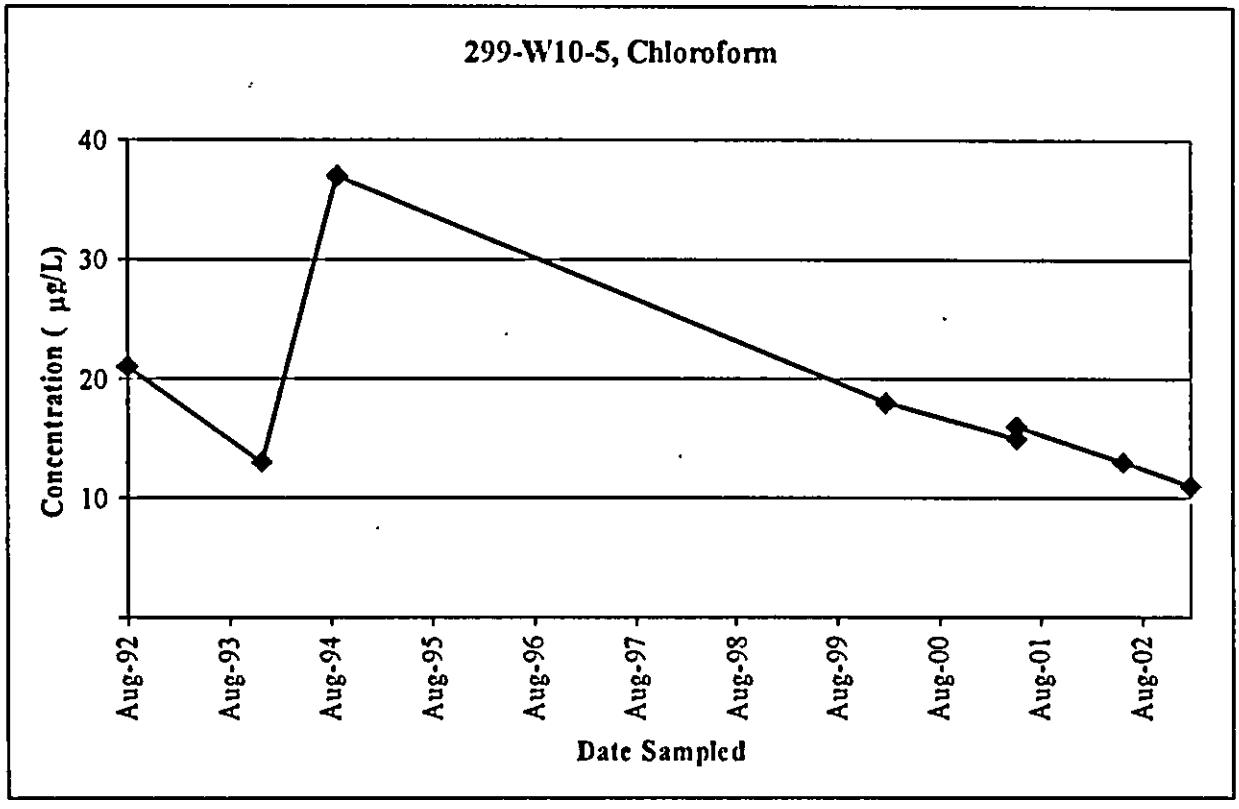

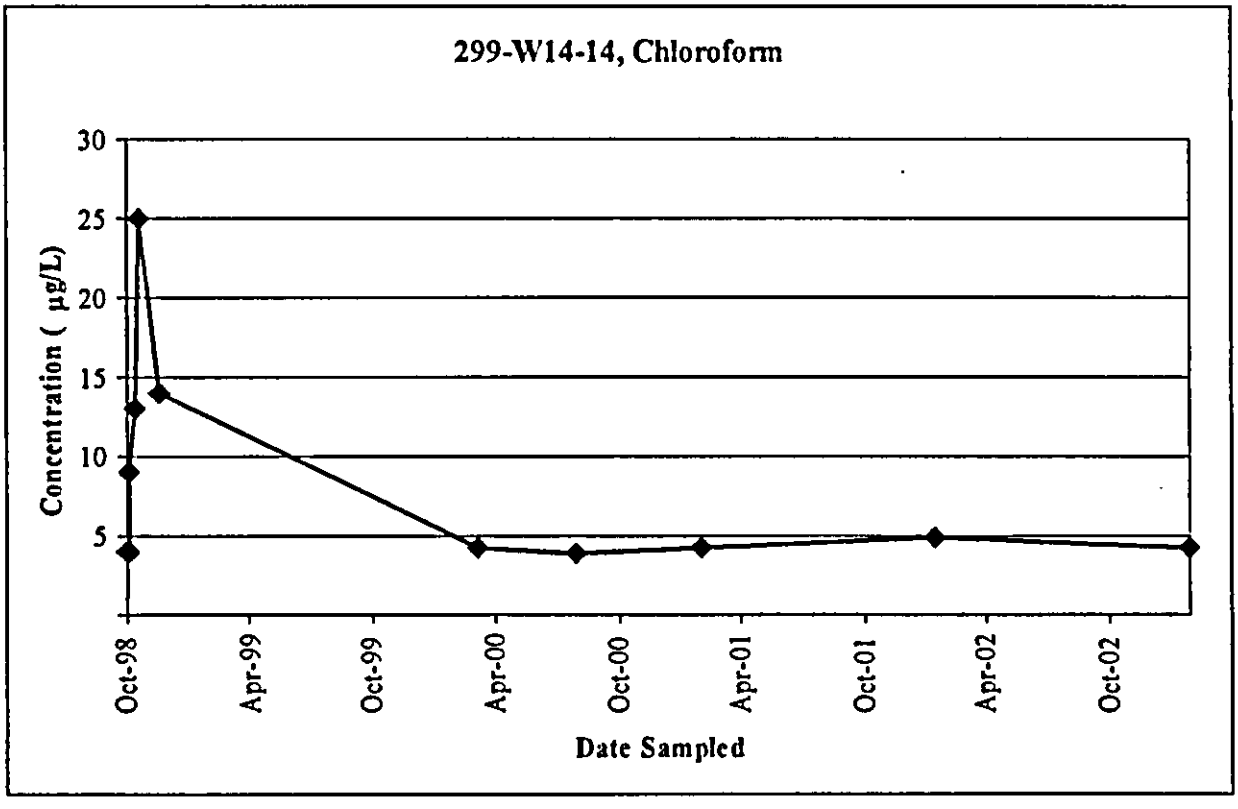

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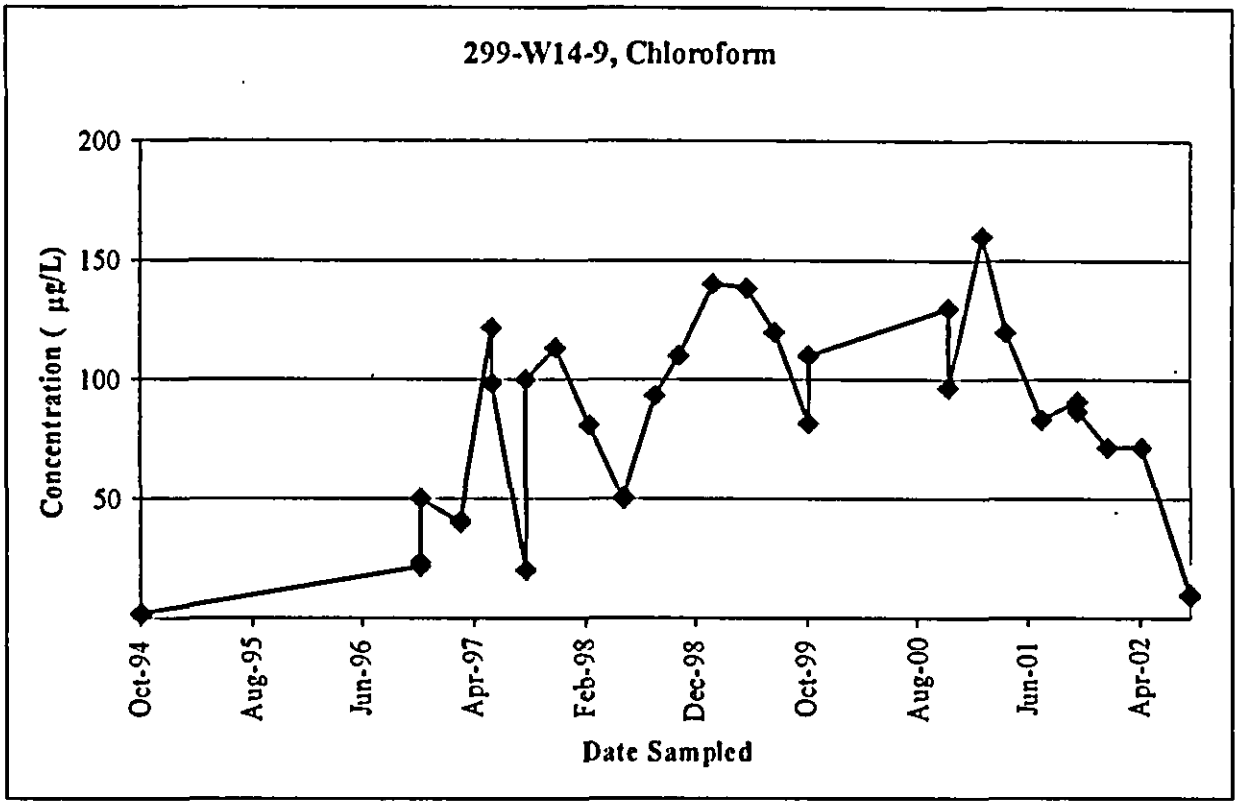

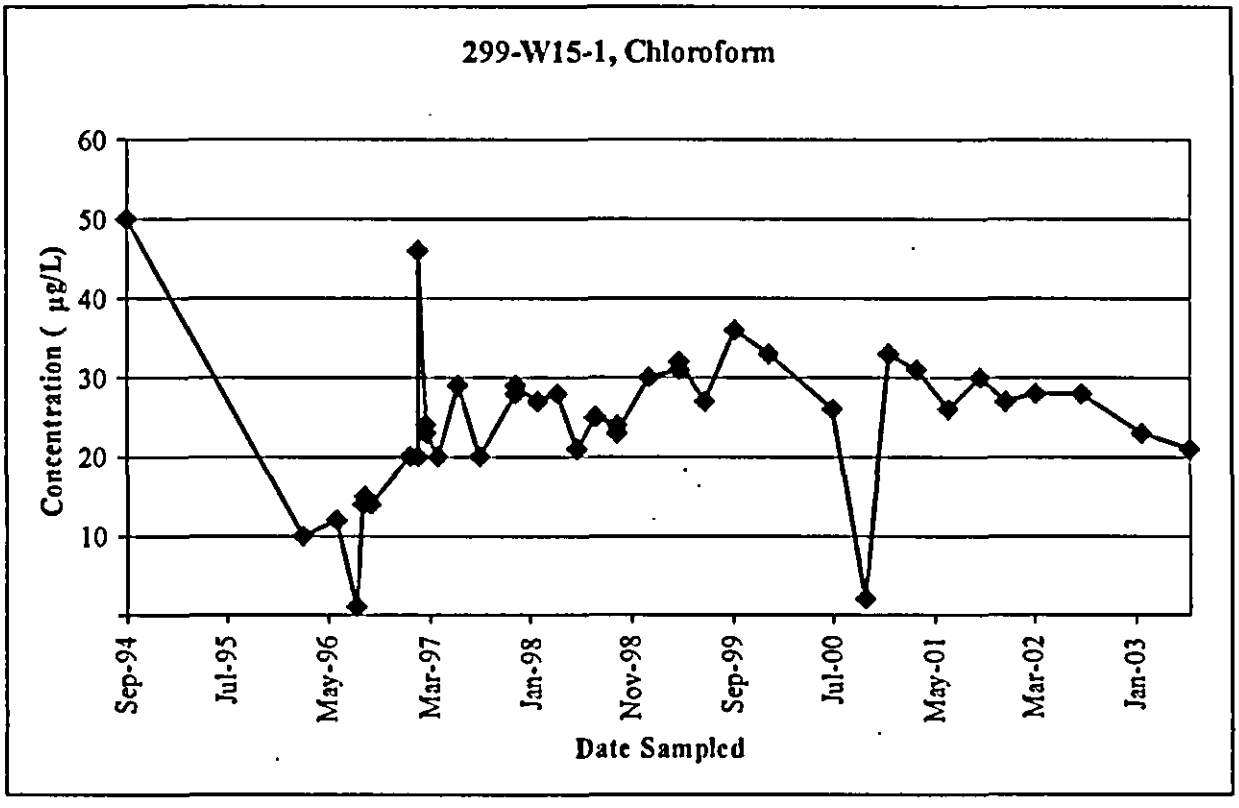

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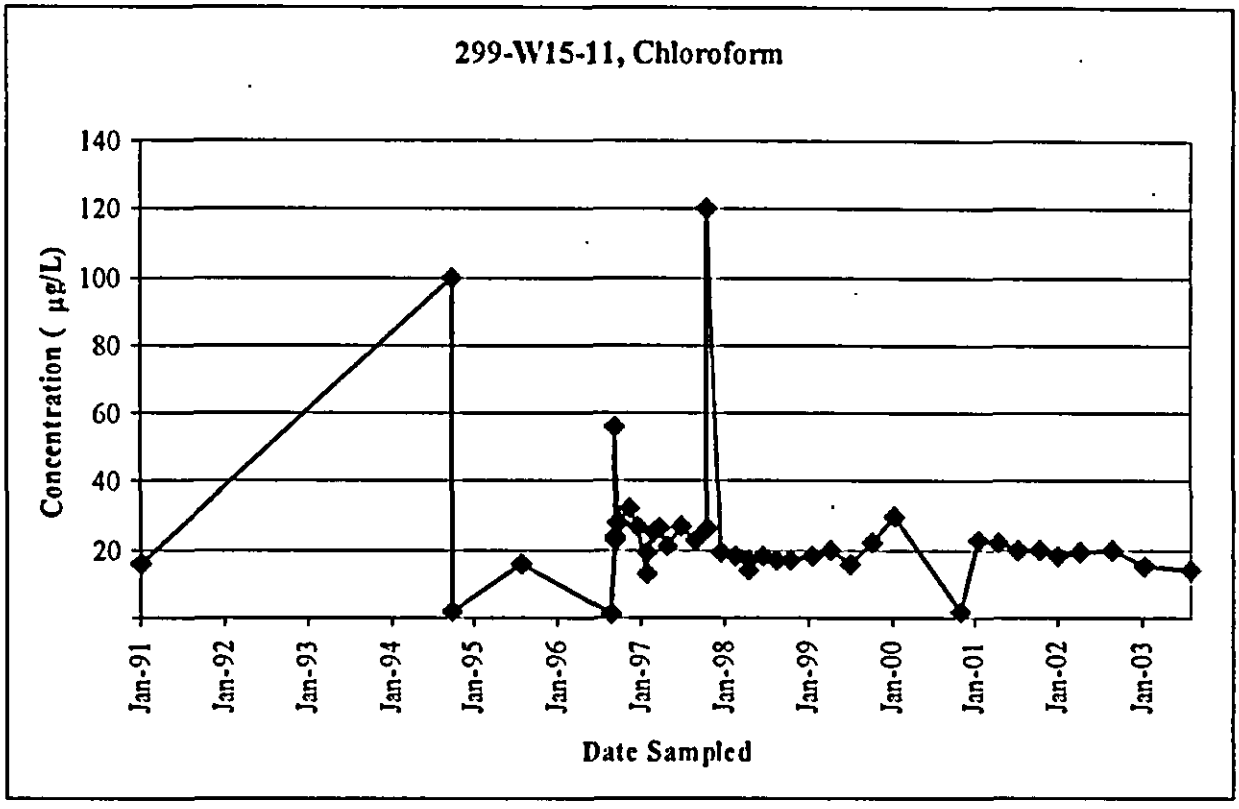

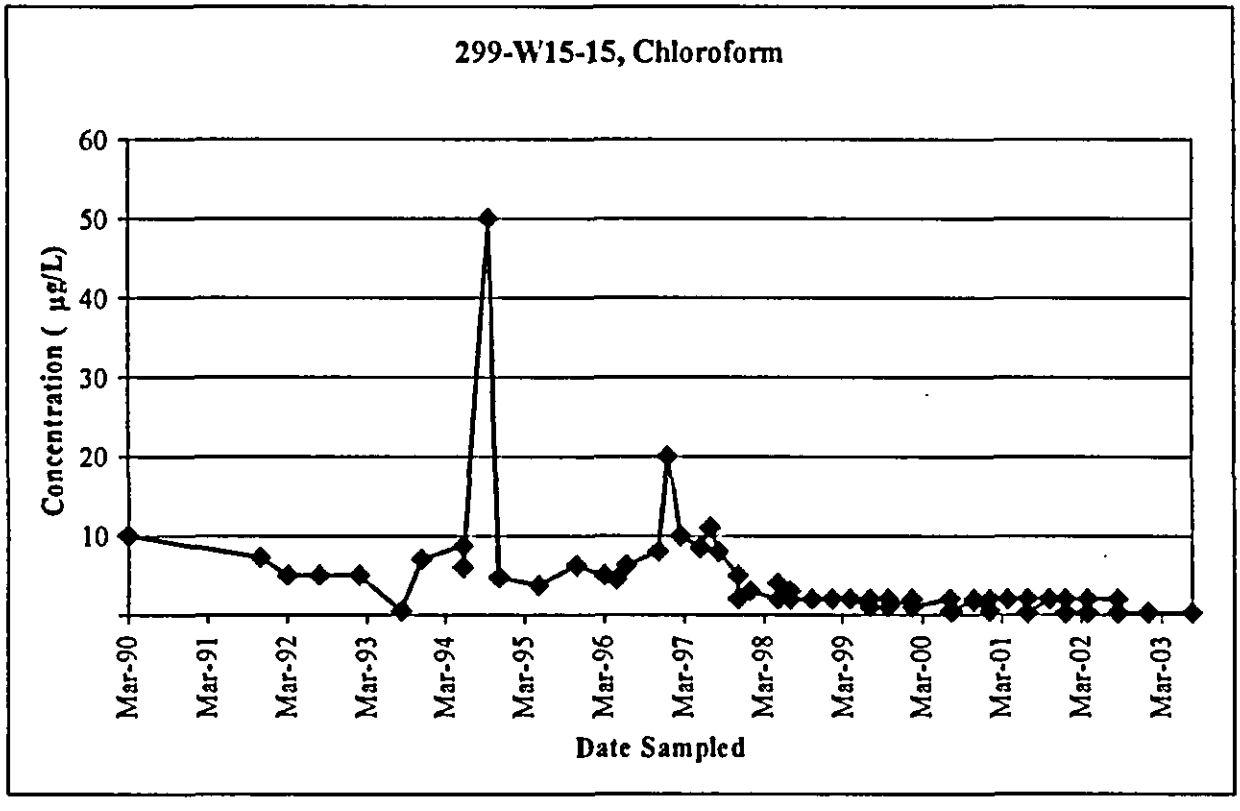

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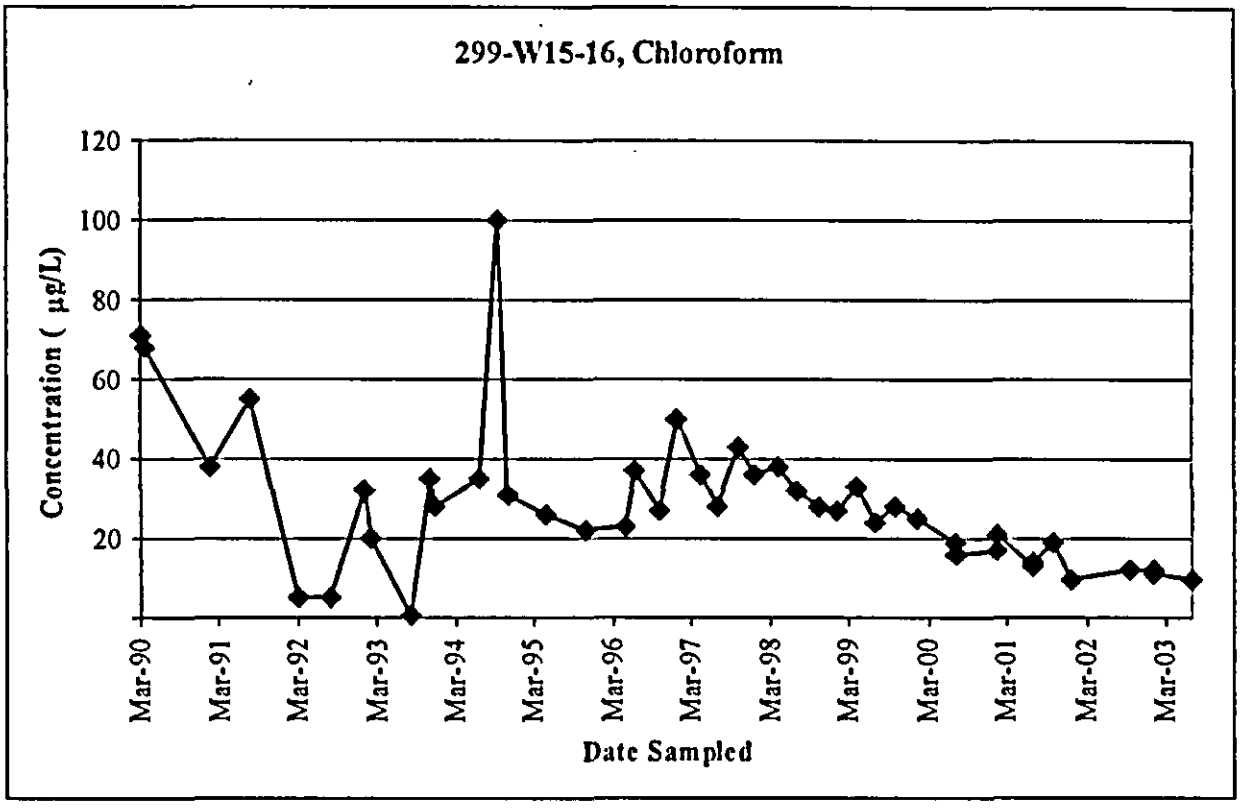

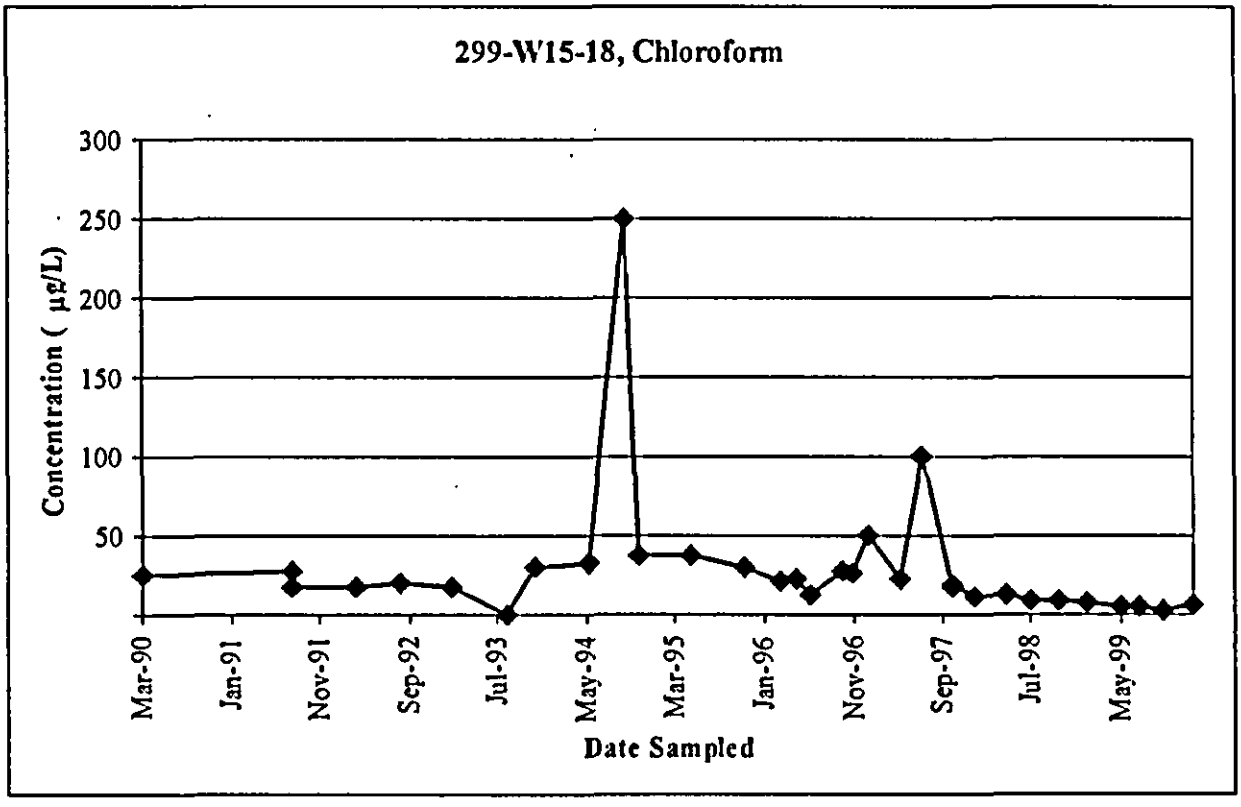

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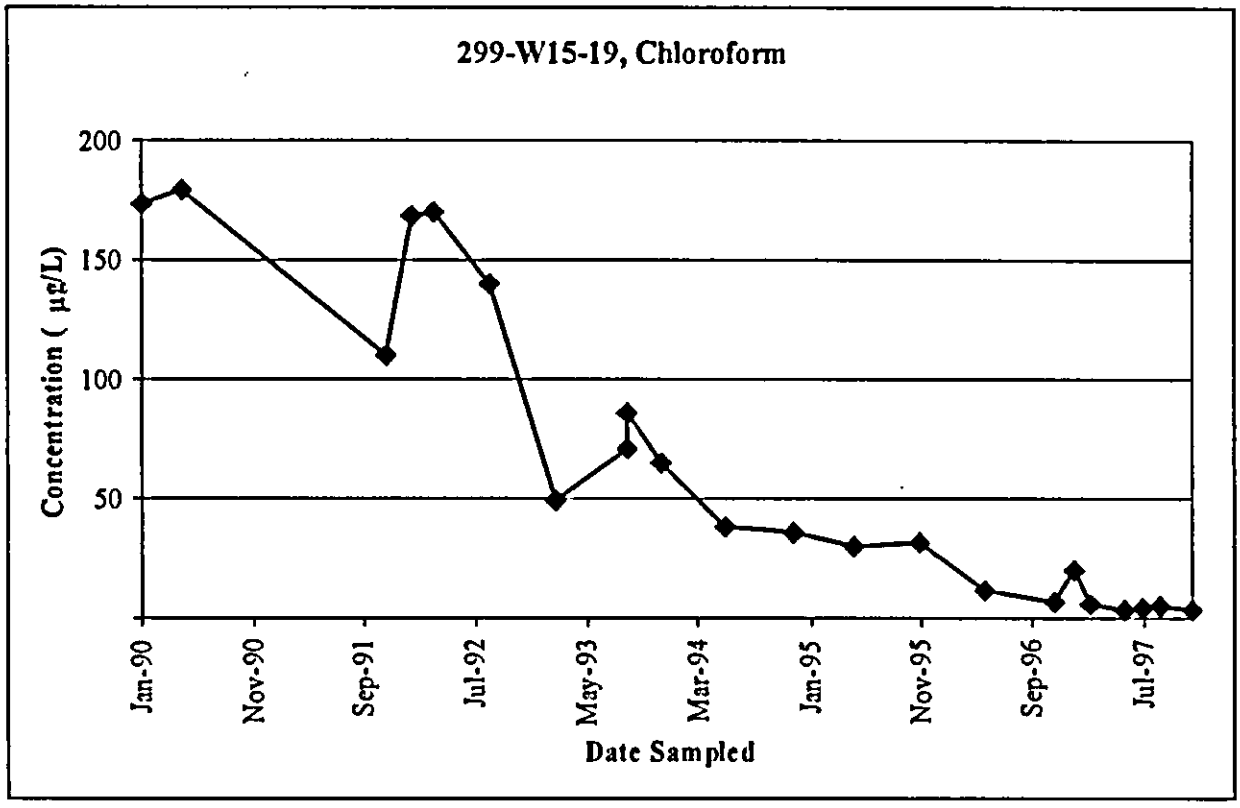

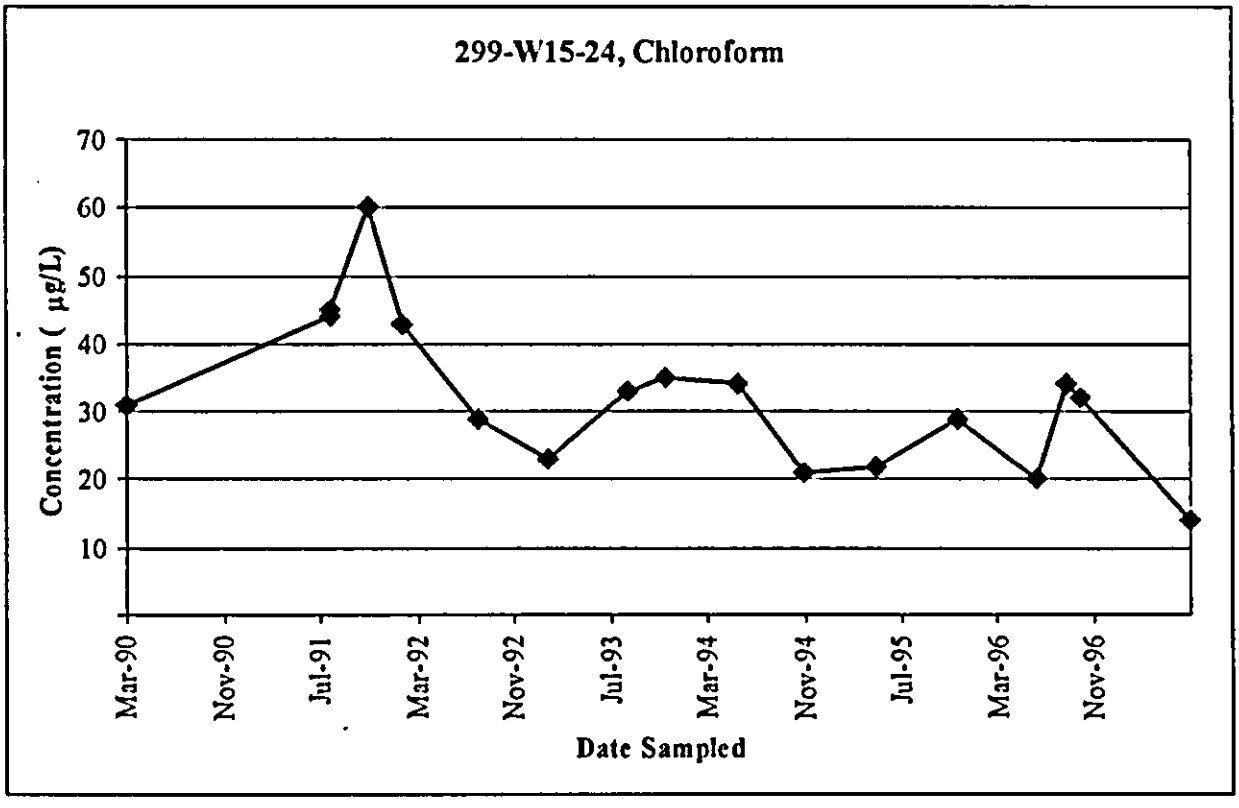

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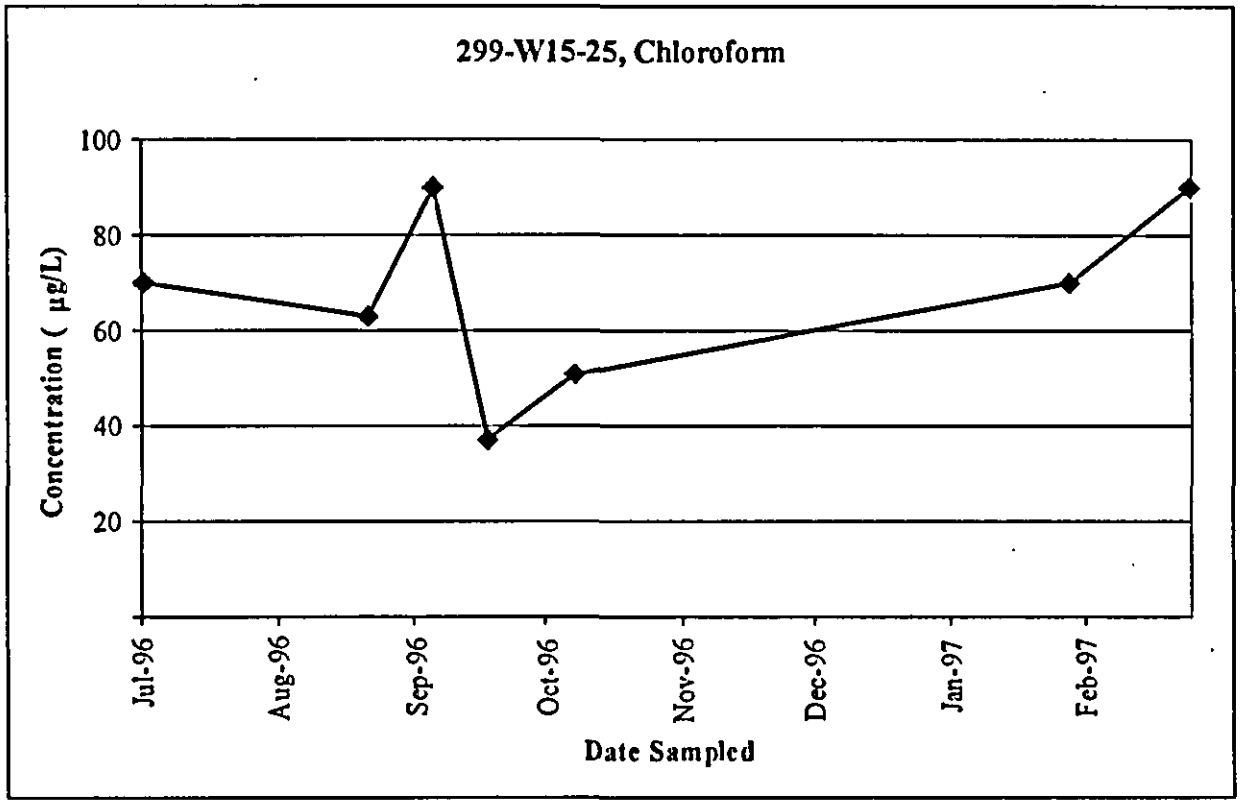

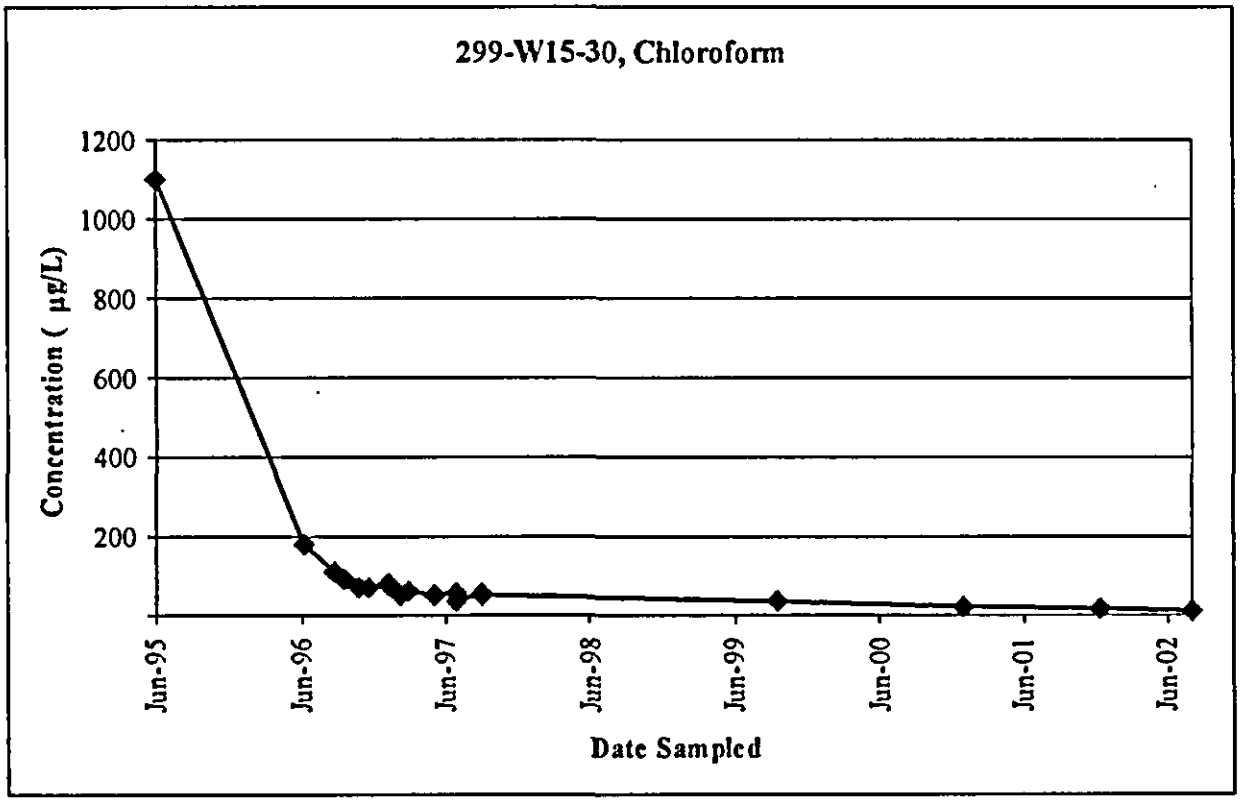

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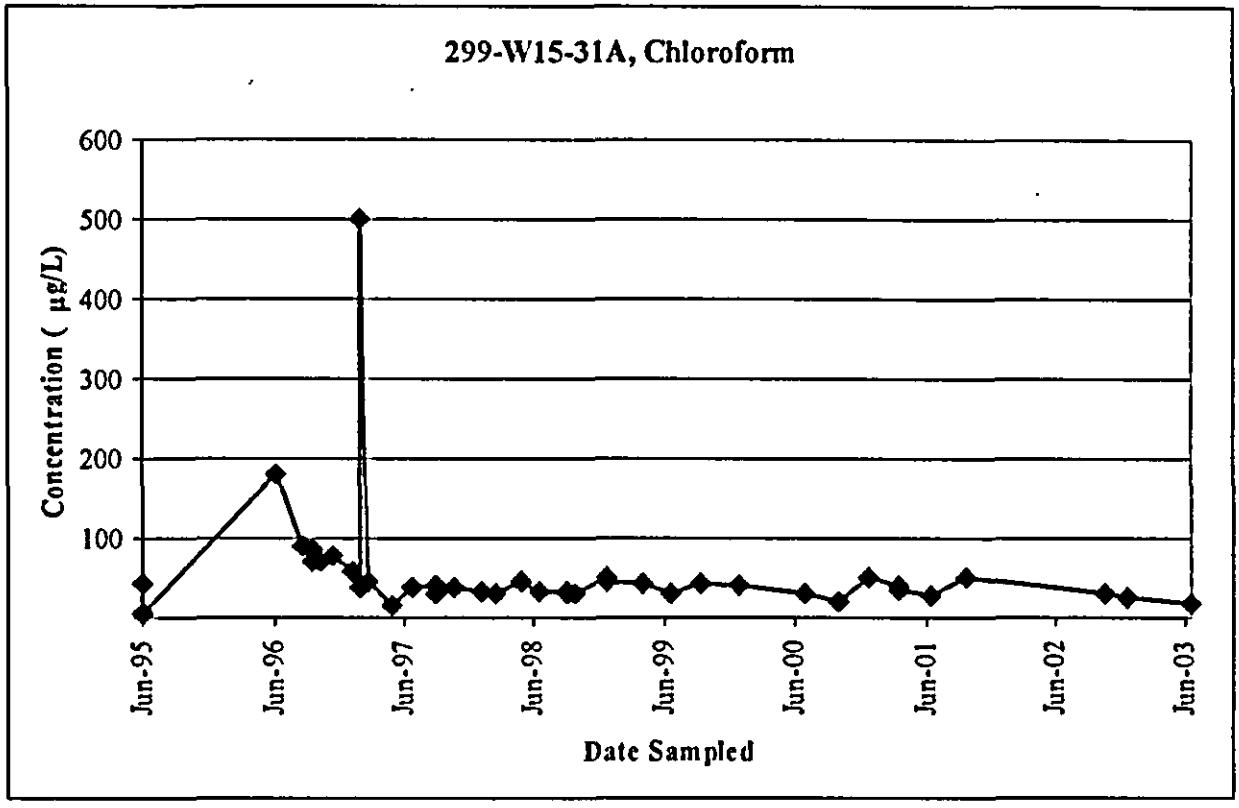

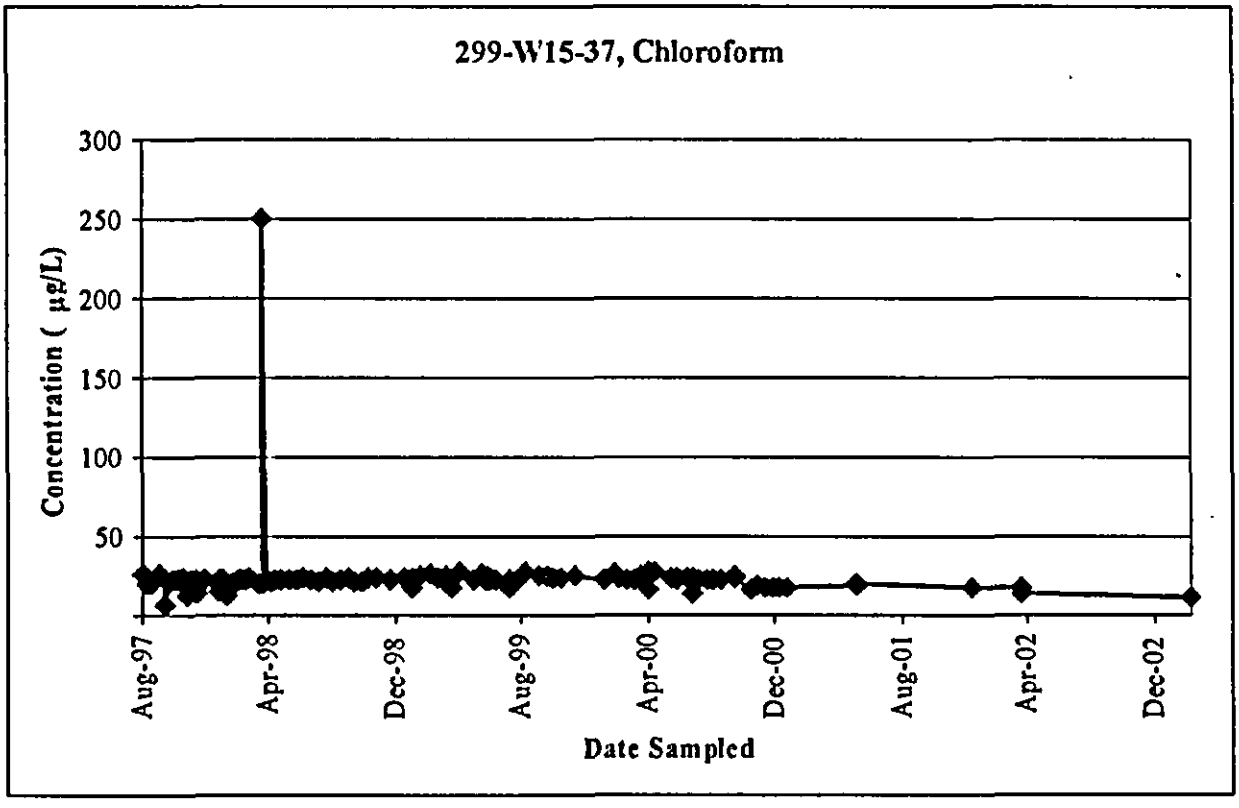

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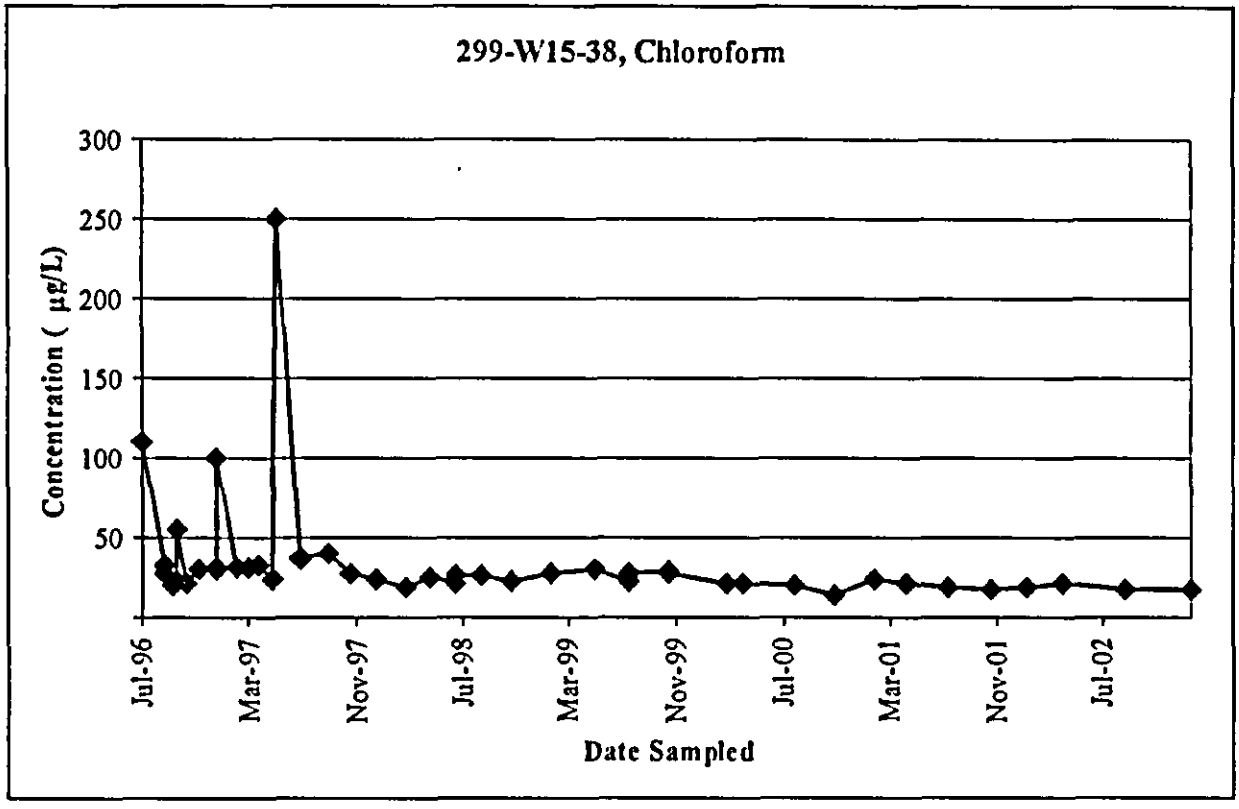

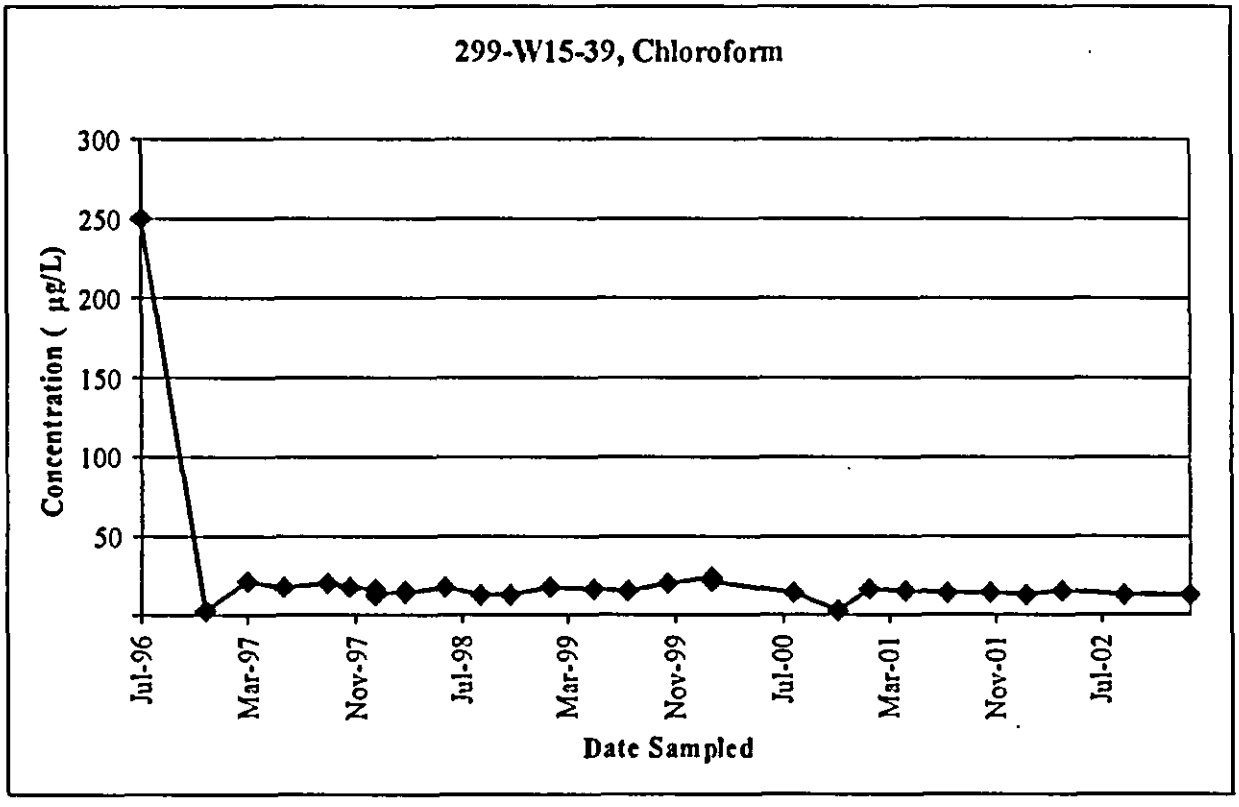

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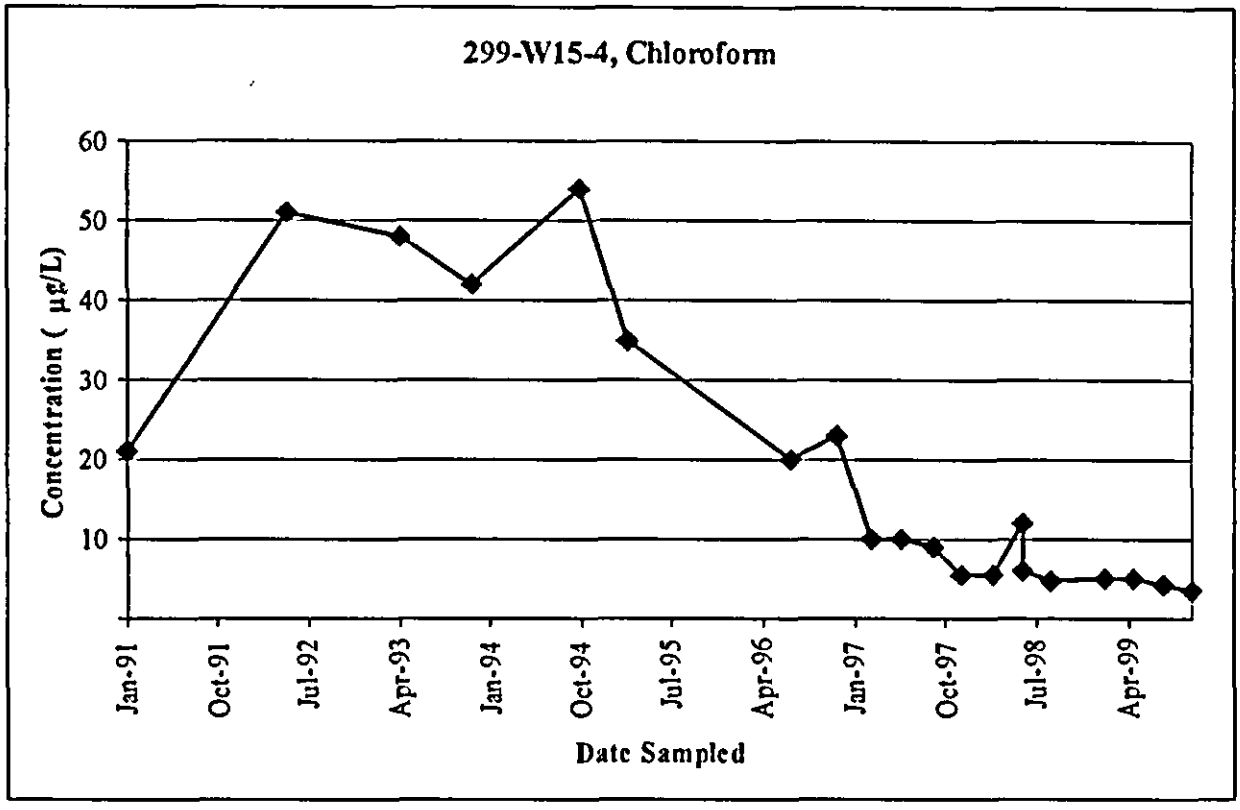

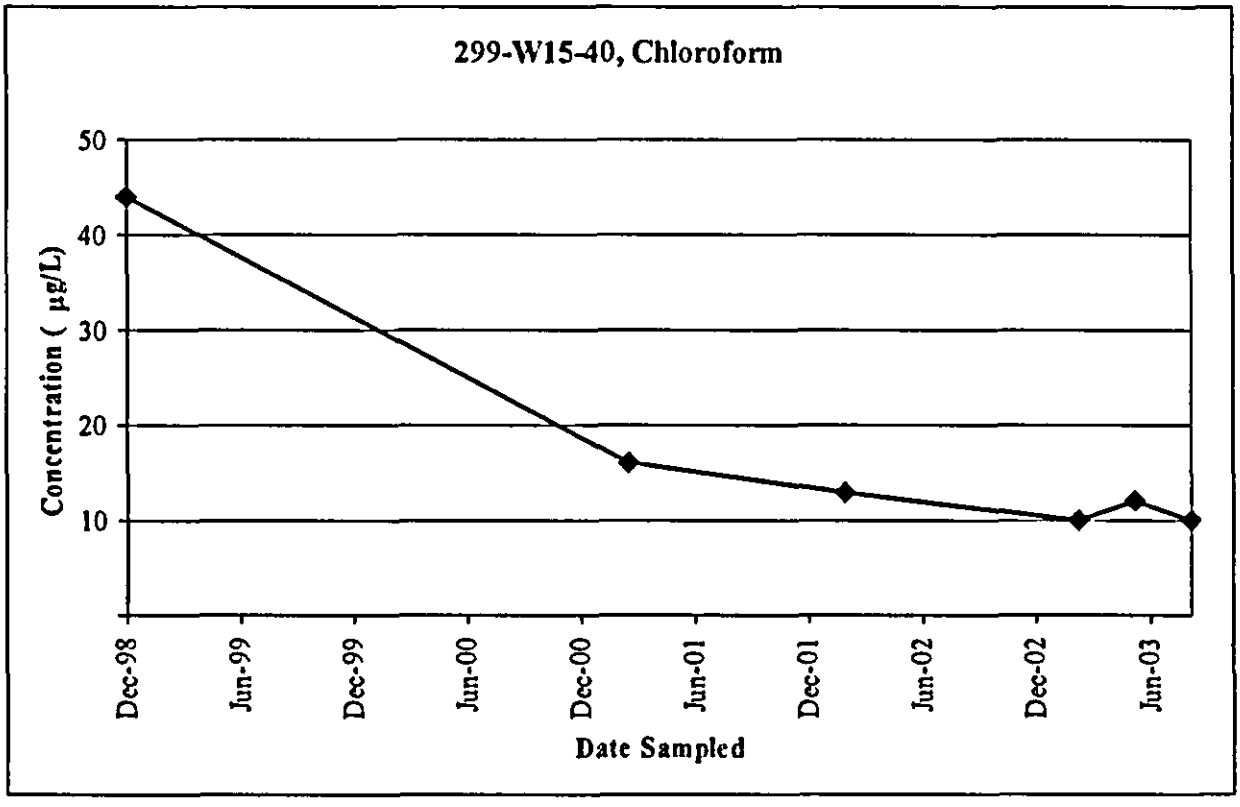

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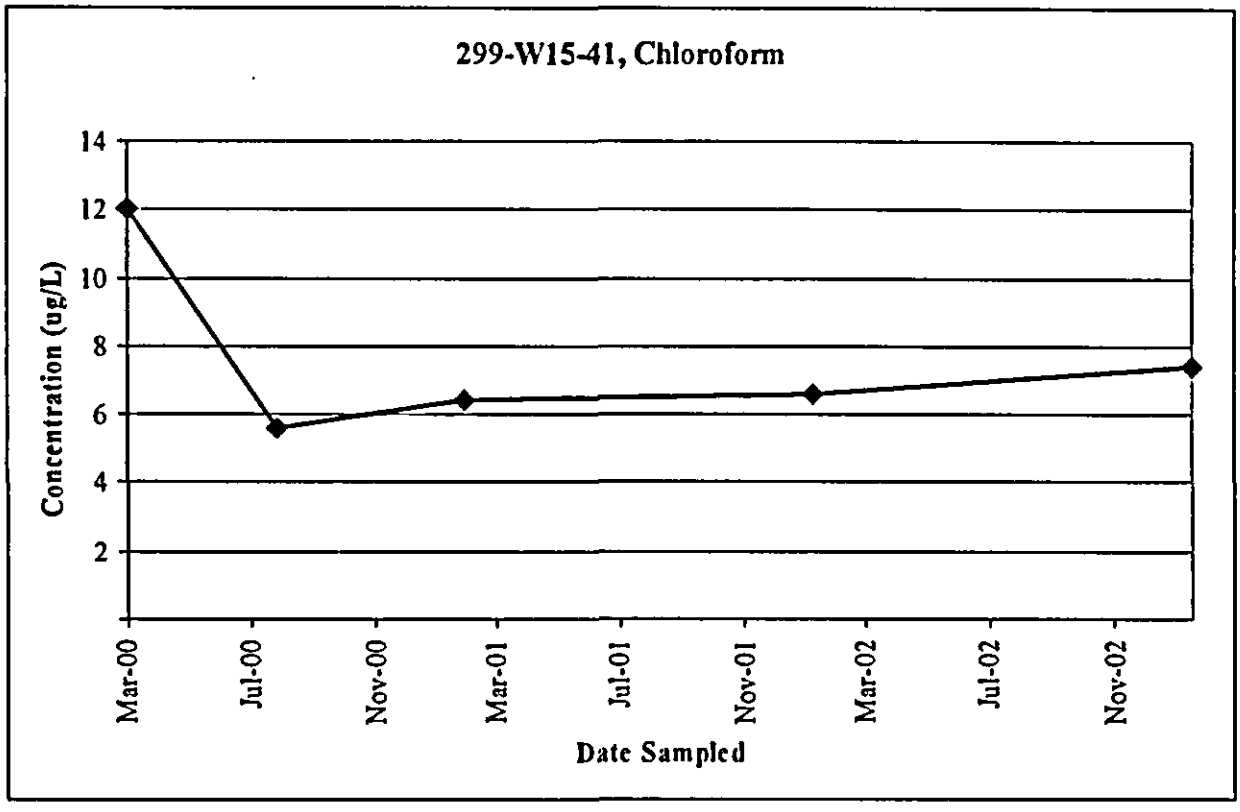

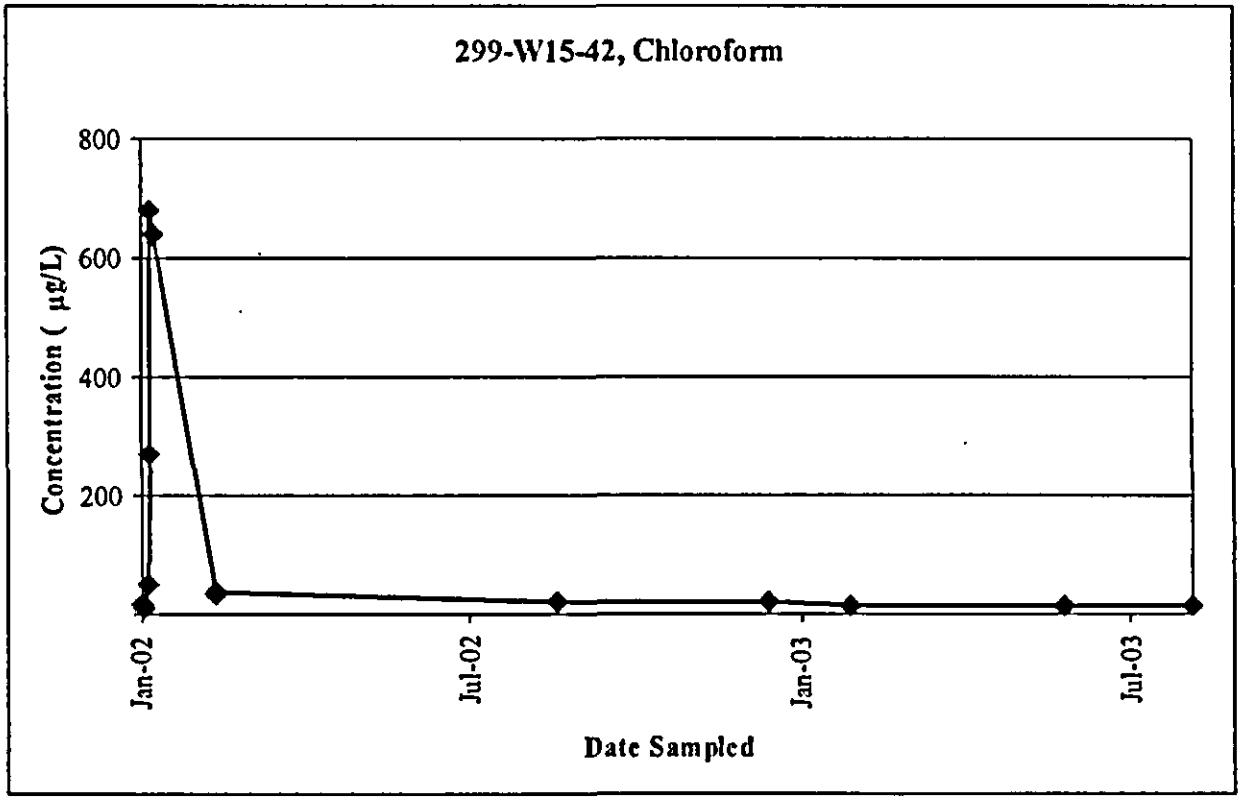

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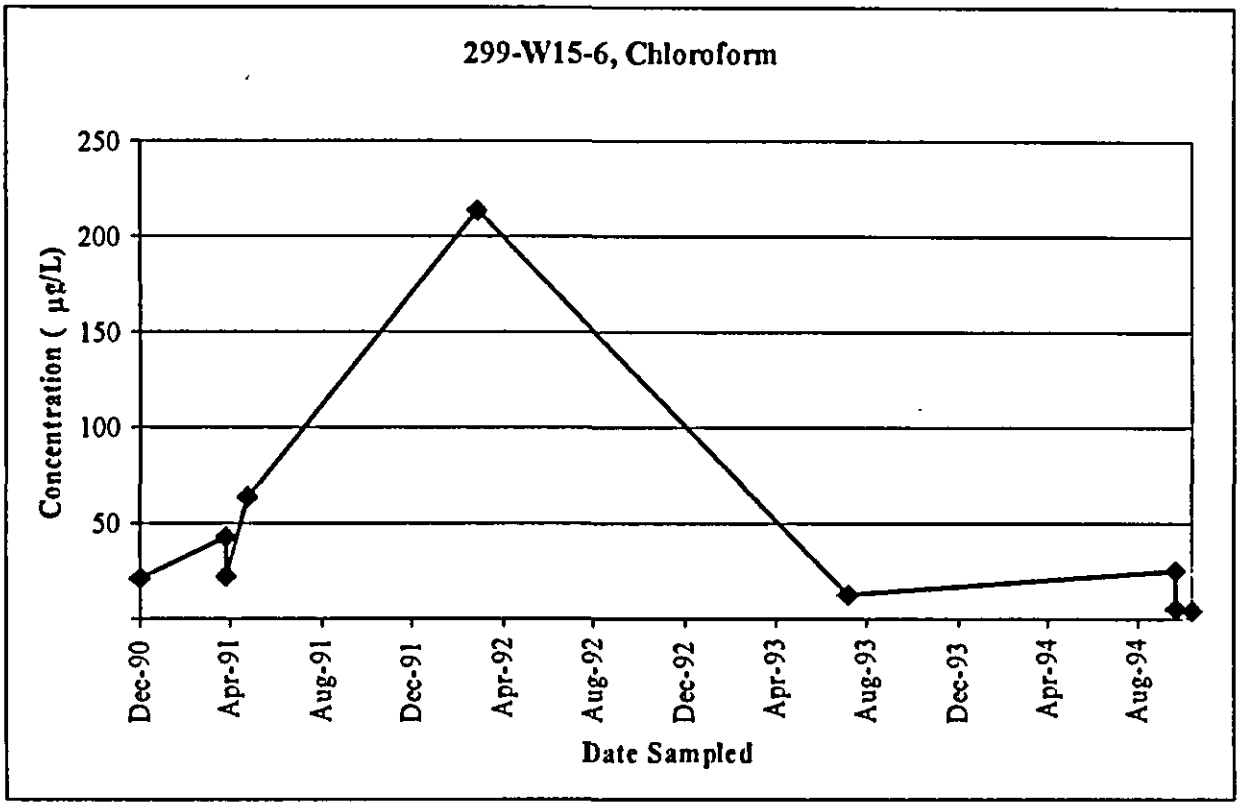

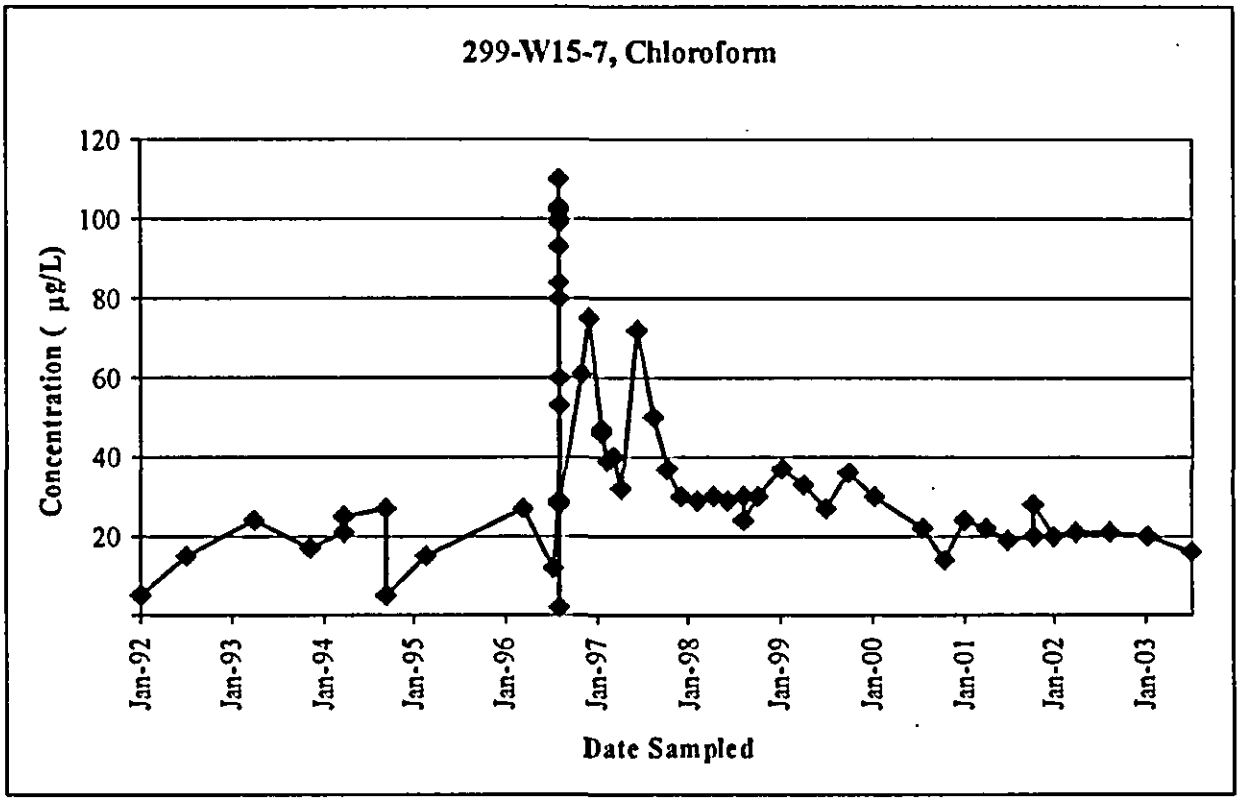

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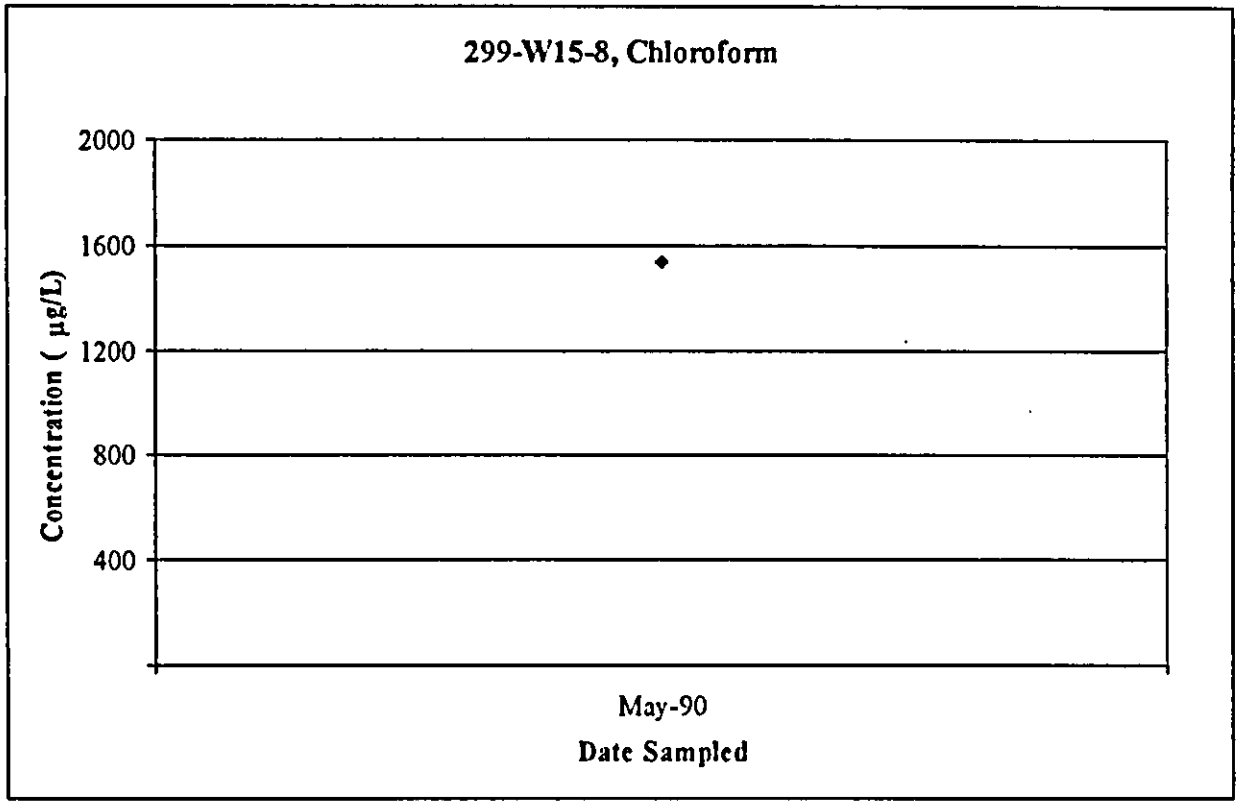

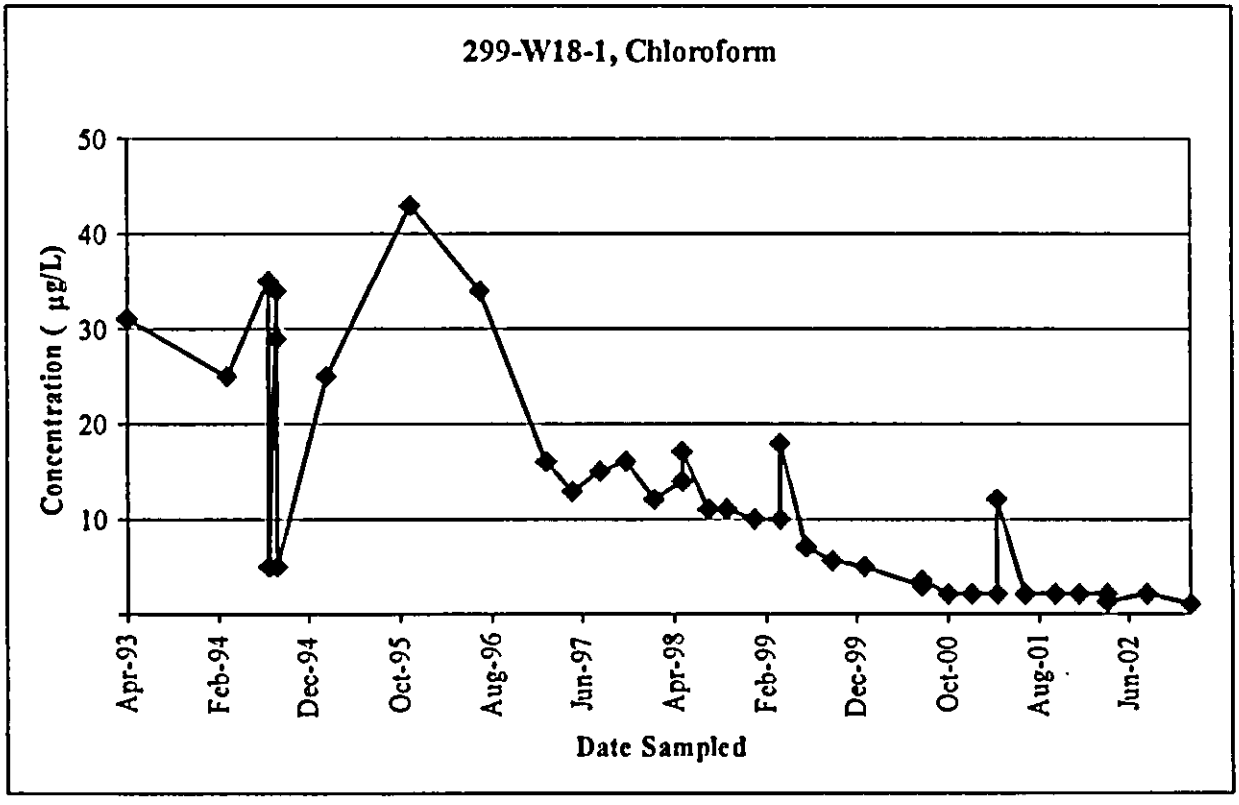

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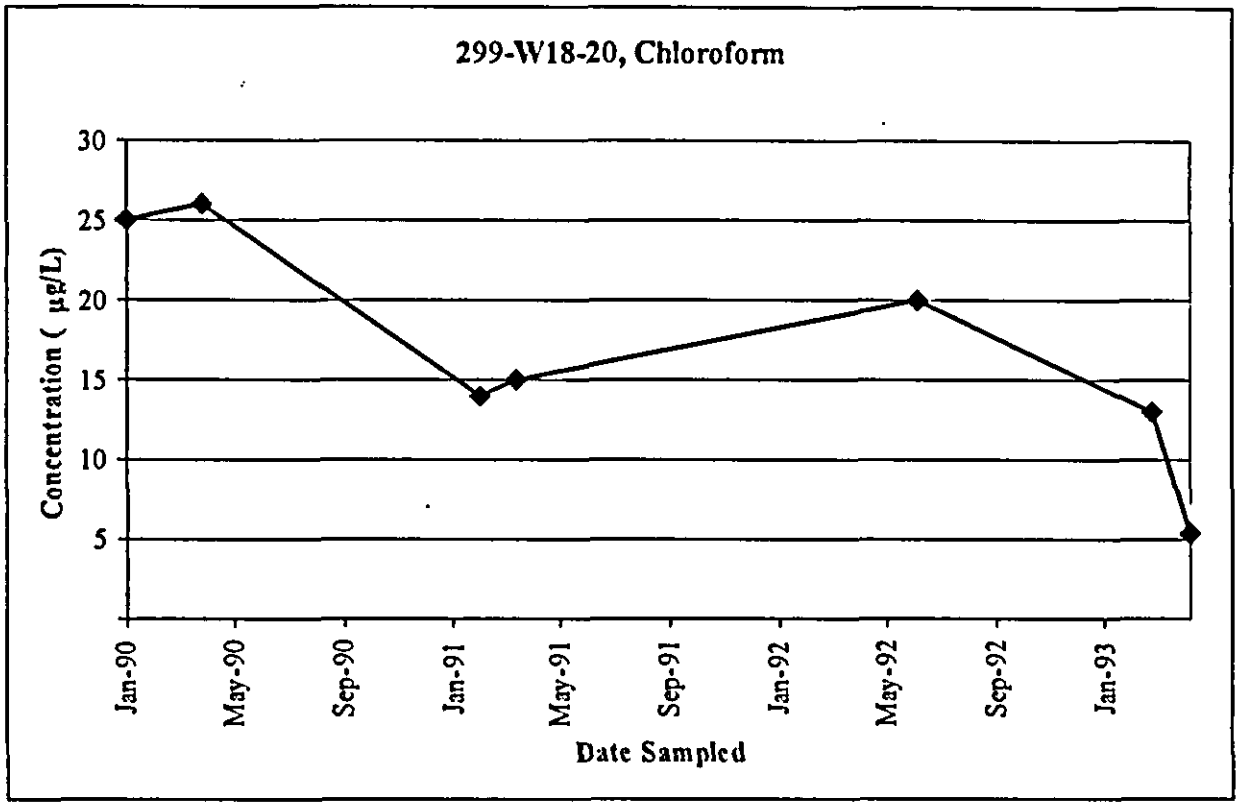

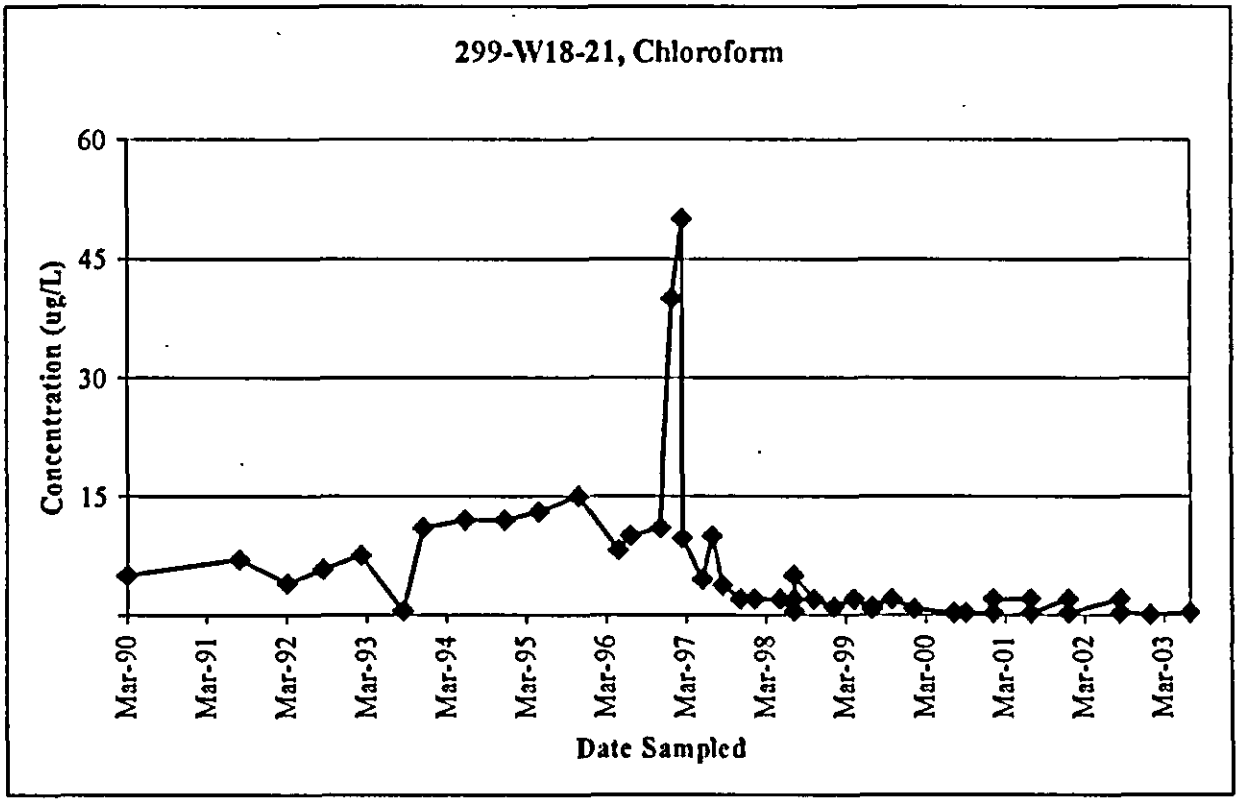

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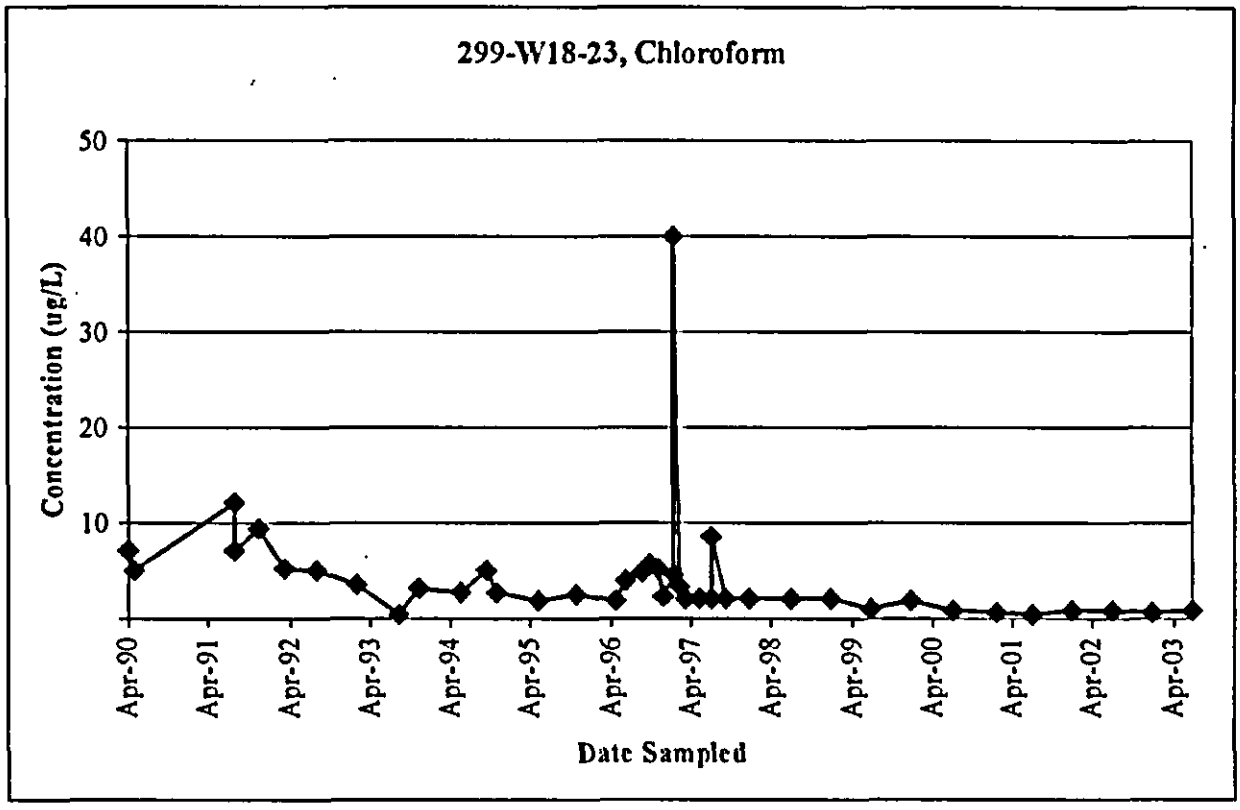

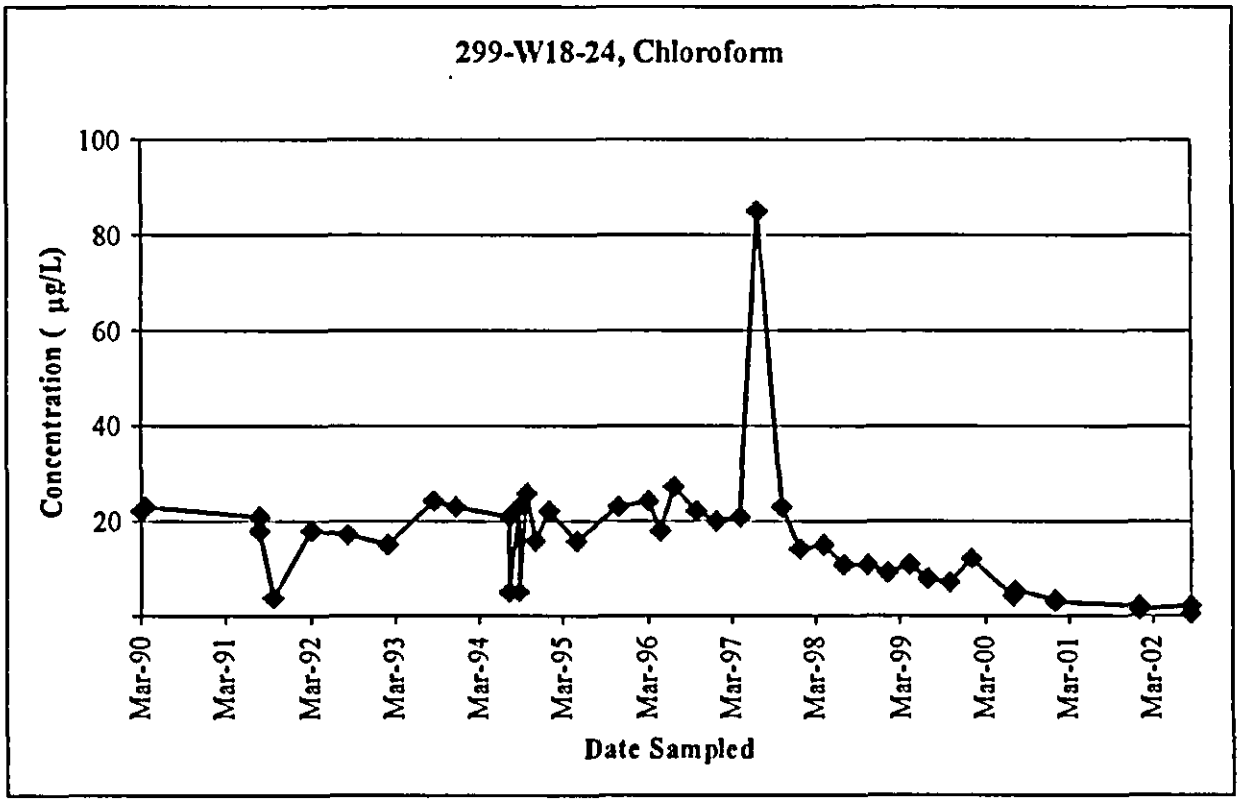

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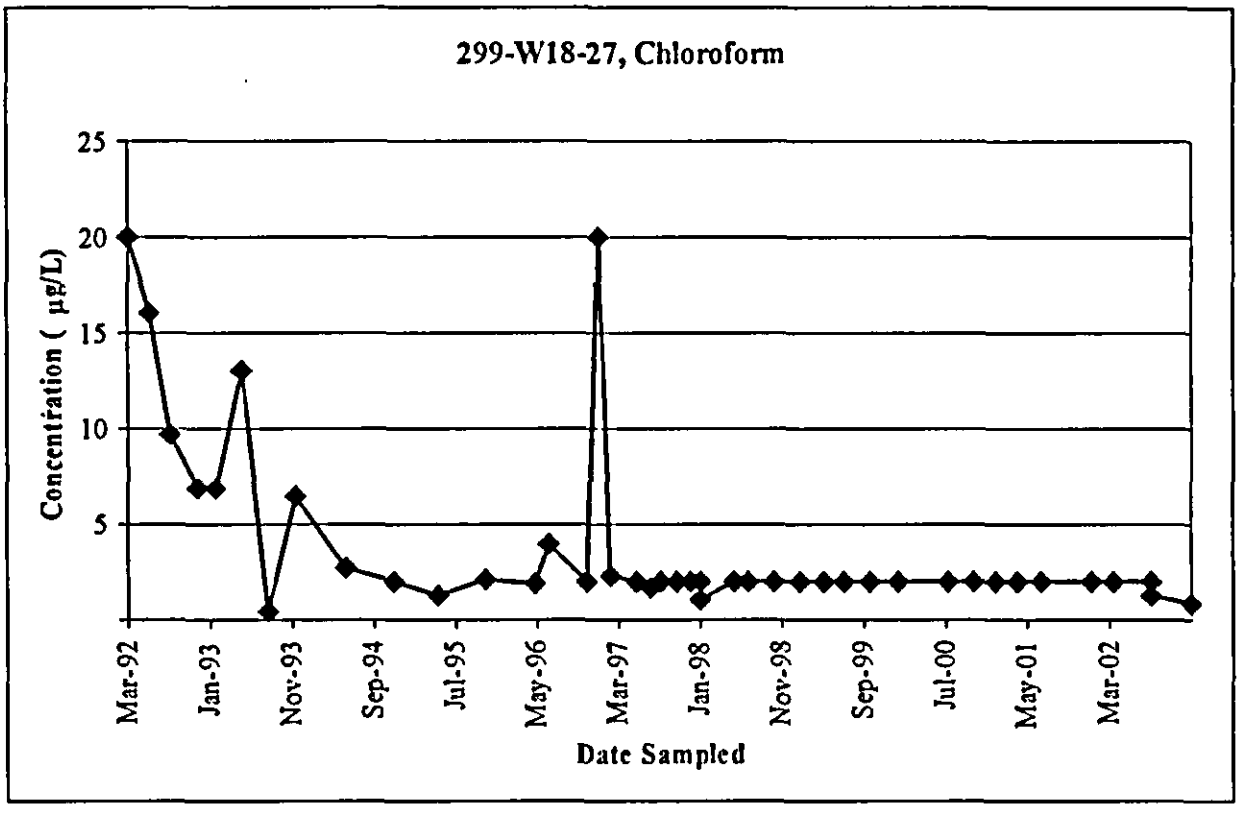


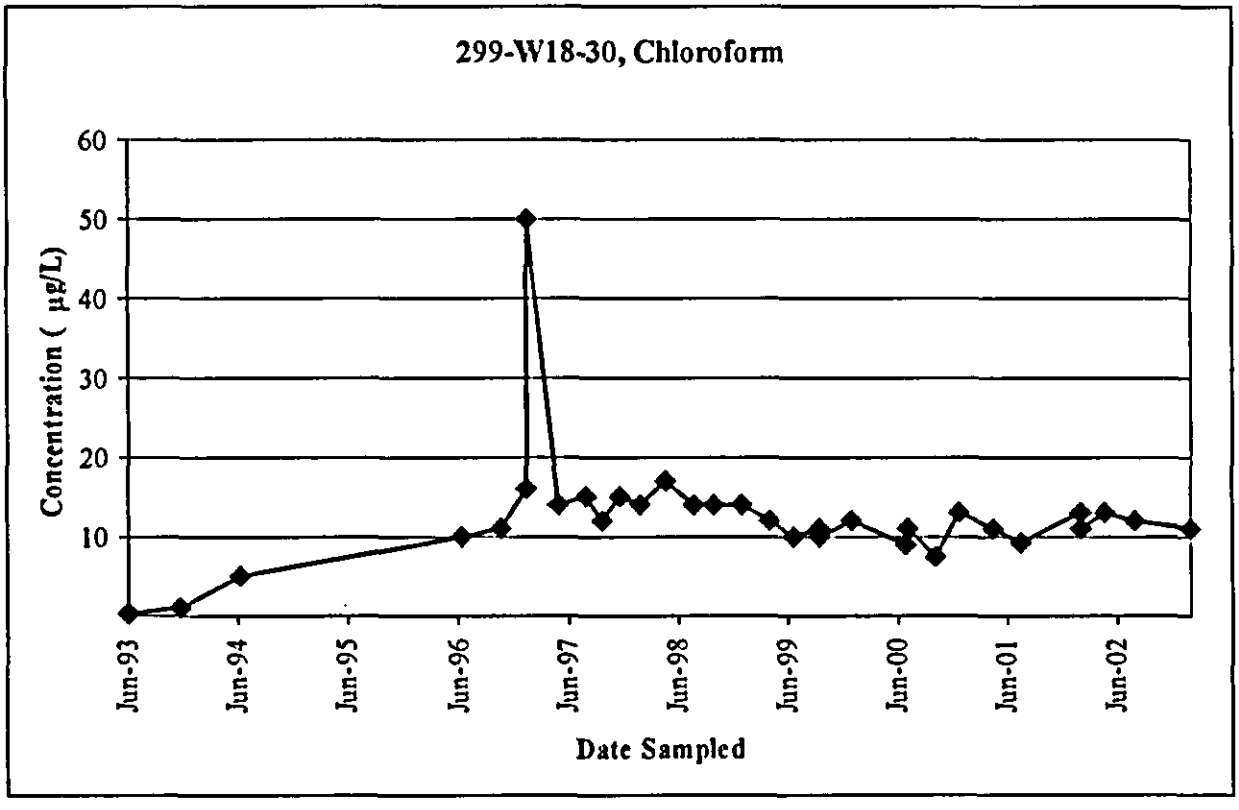
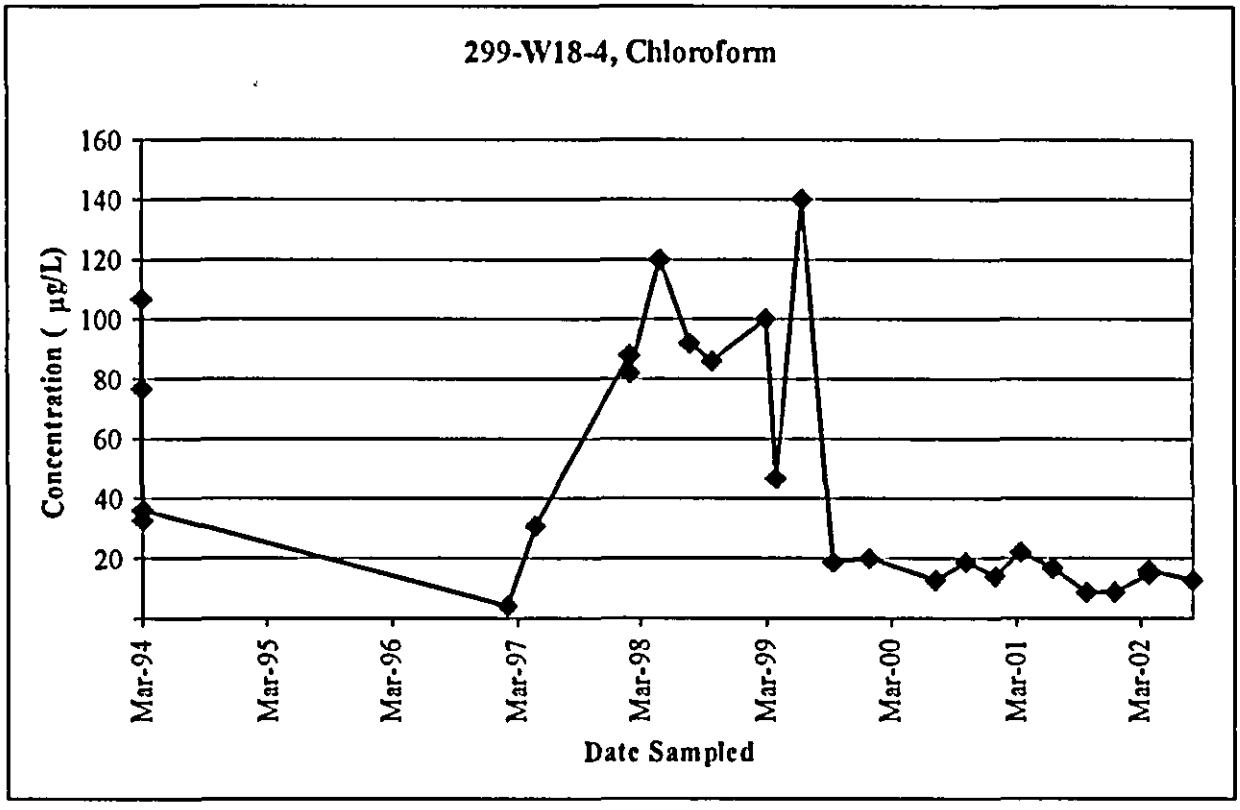
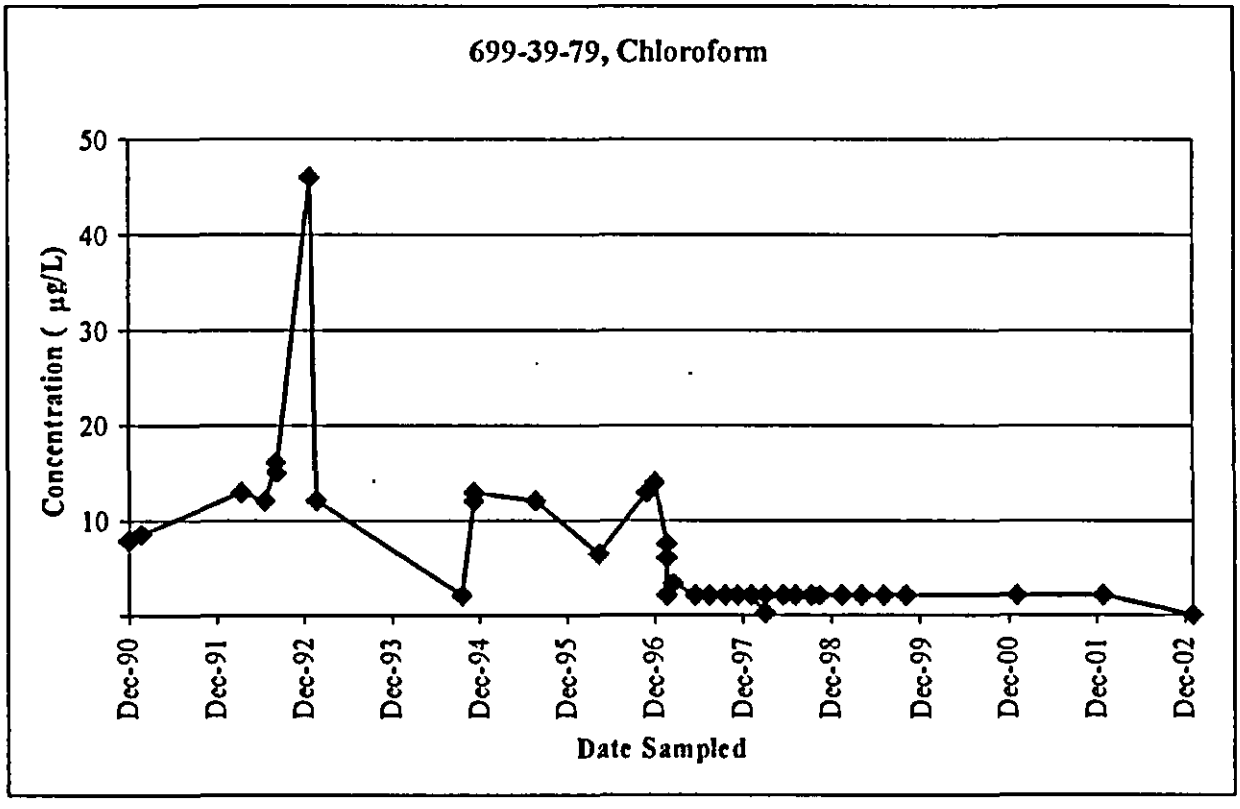


Figure H-2. 200-ZP-1 Groundwater Operable Unit, Chloroform Concentration Trends at Selected Monitoring Wells. (17 sheets)





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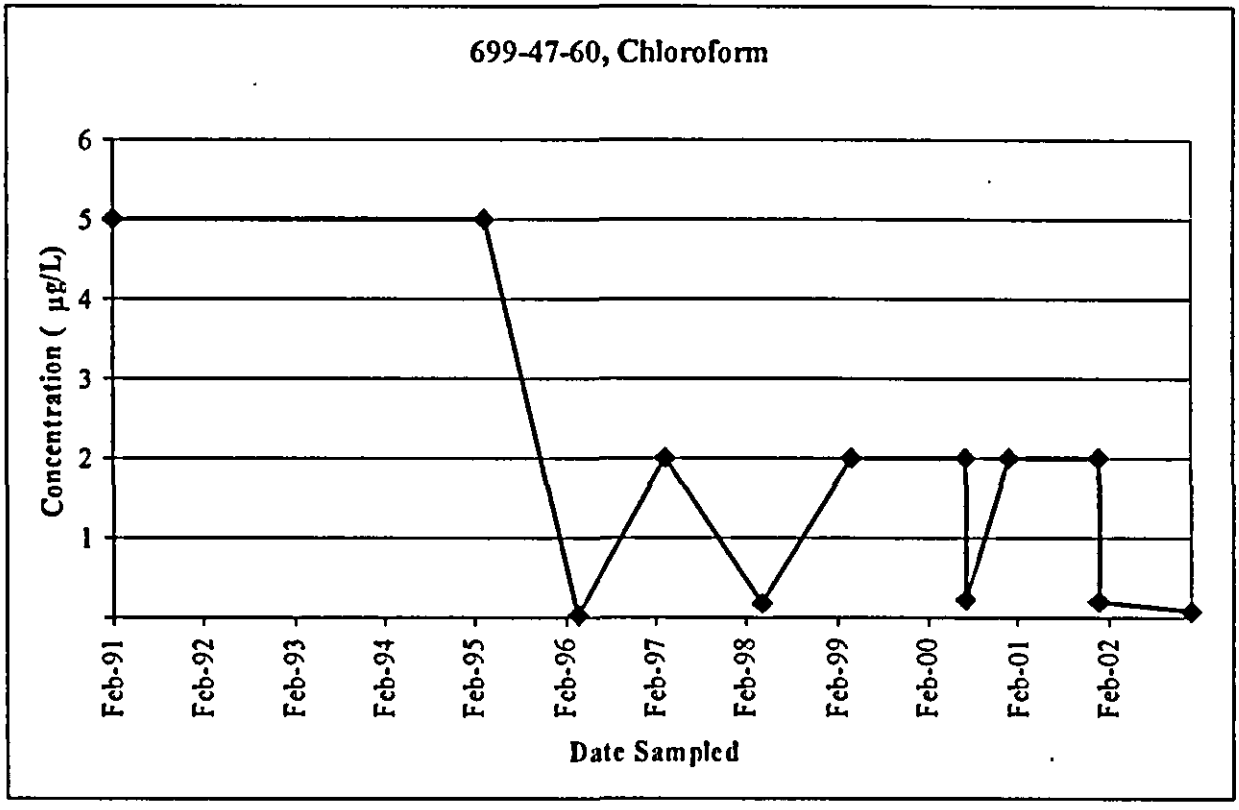


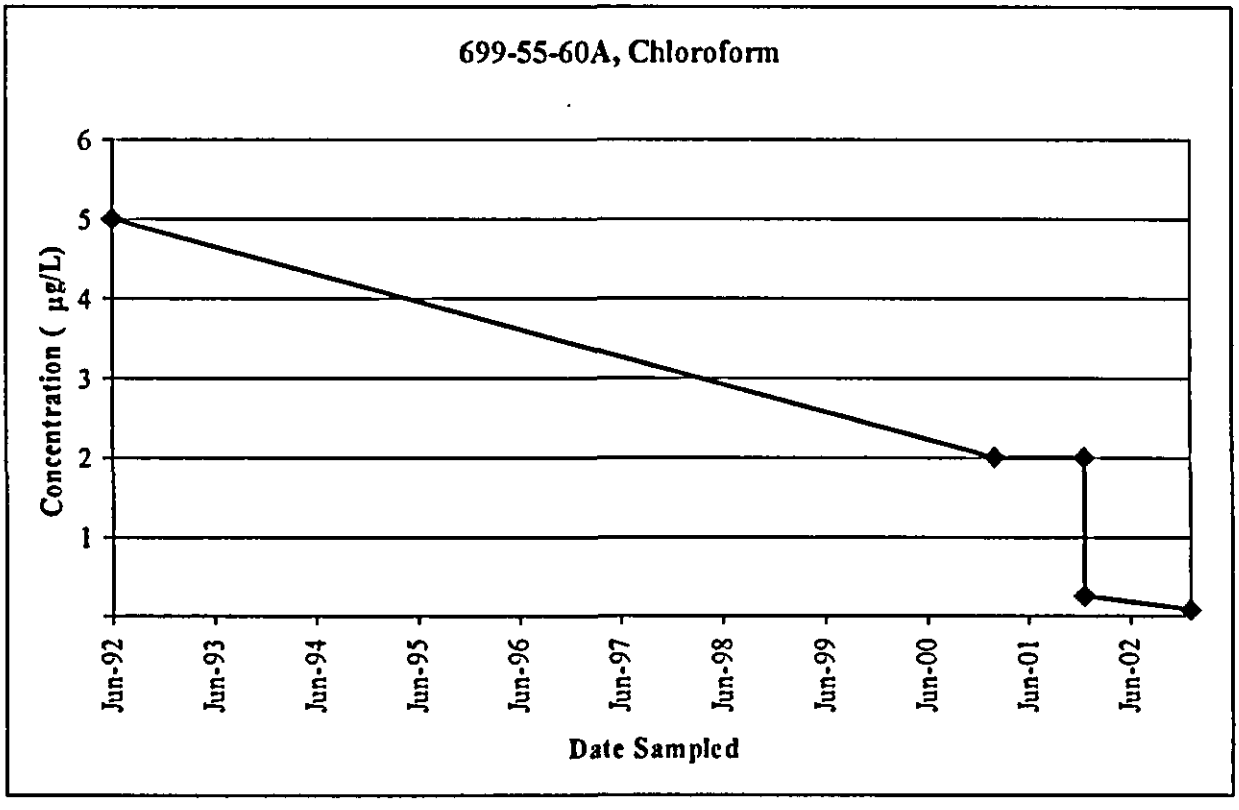
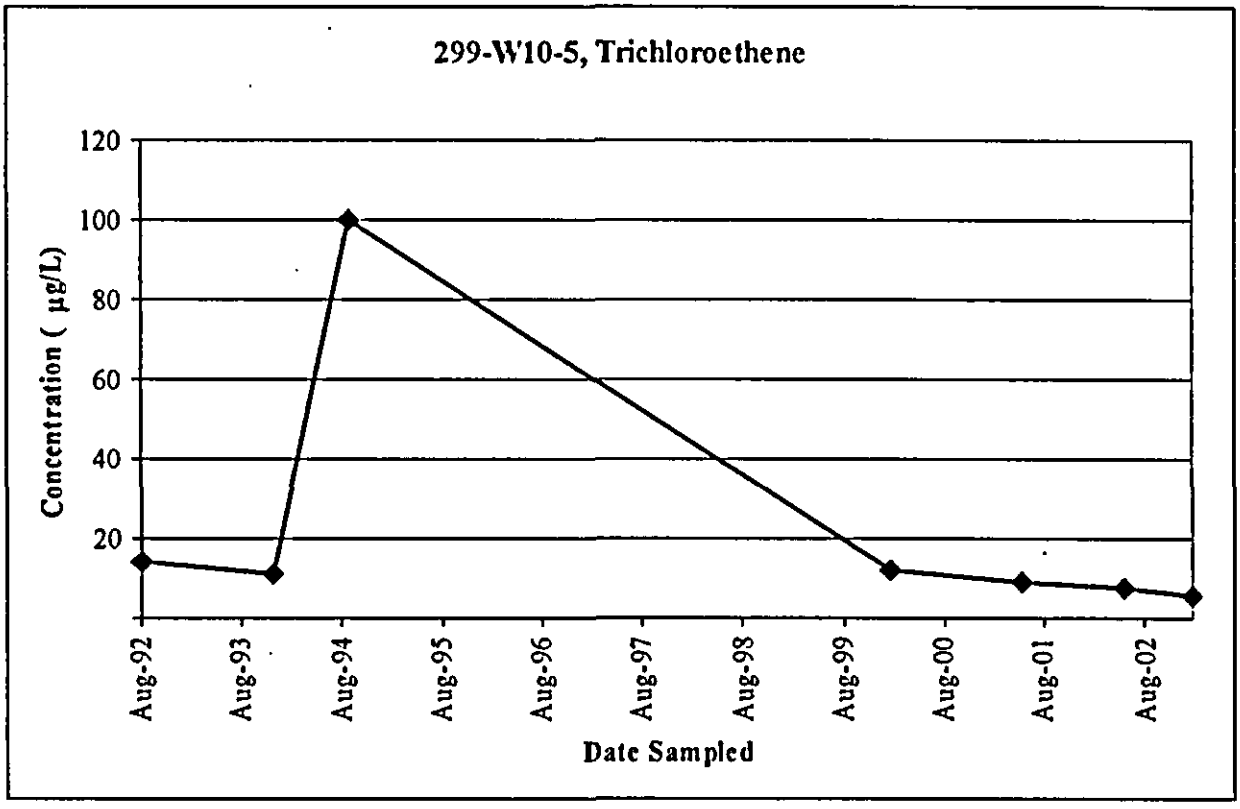


Figure H-3. 200-ZP-1 Groundwater Operable Unit, Trichloroethene Concentration Trends at Selected Monitoring Wells. (17 sheets)



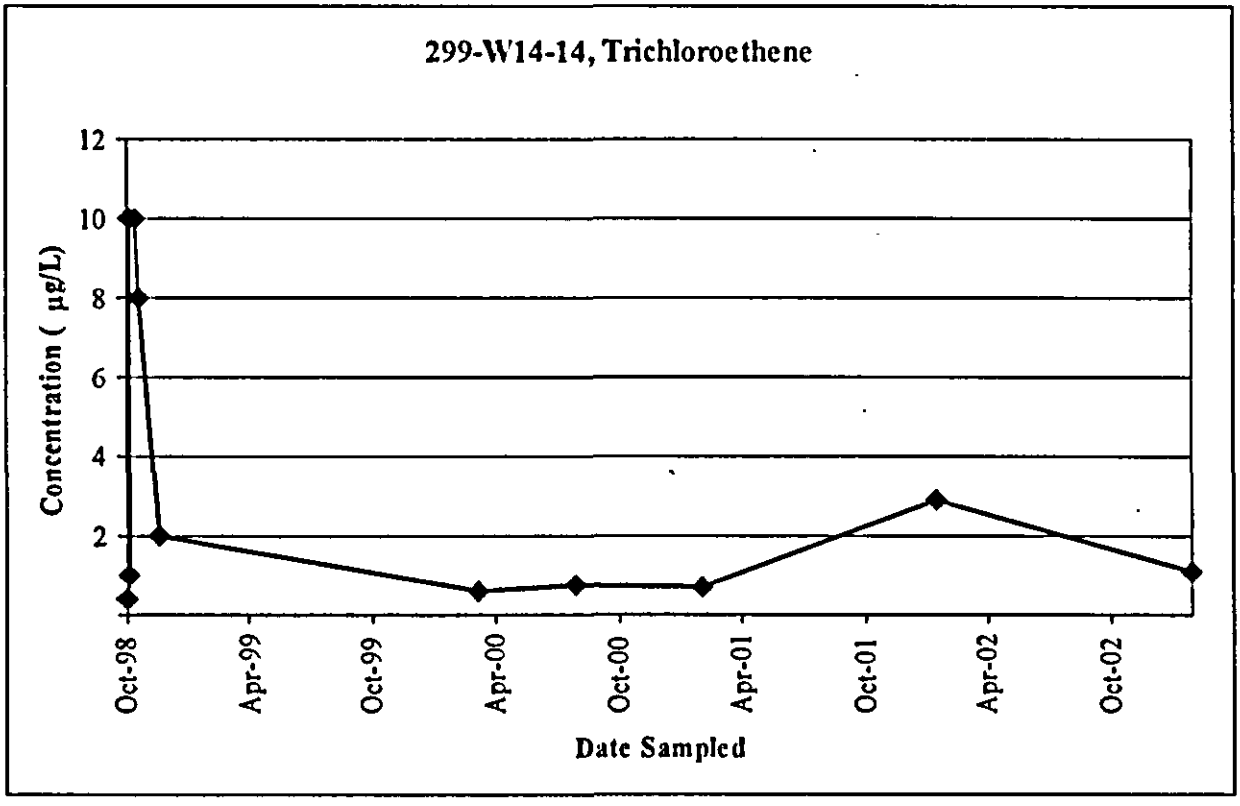
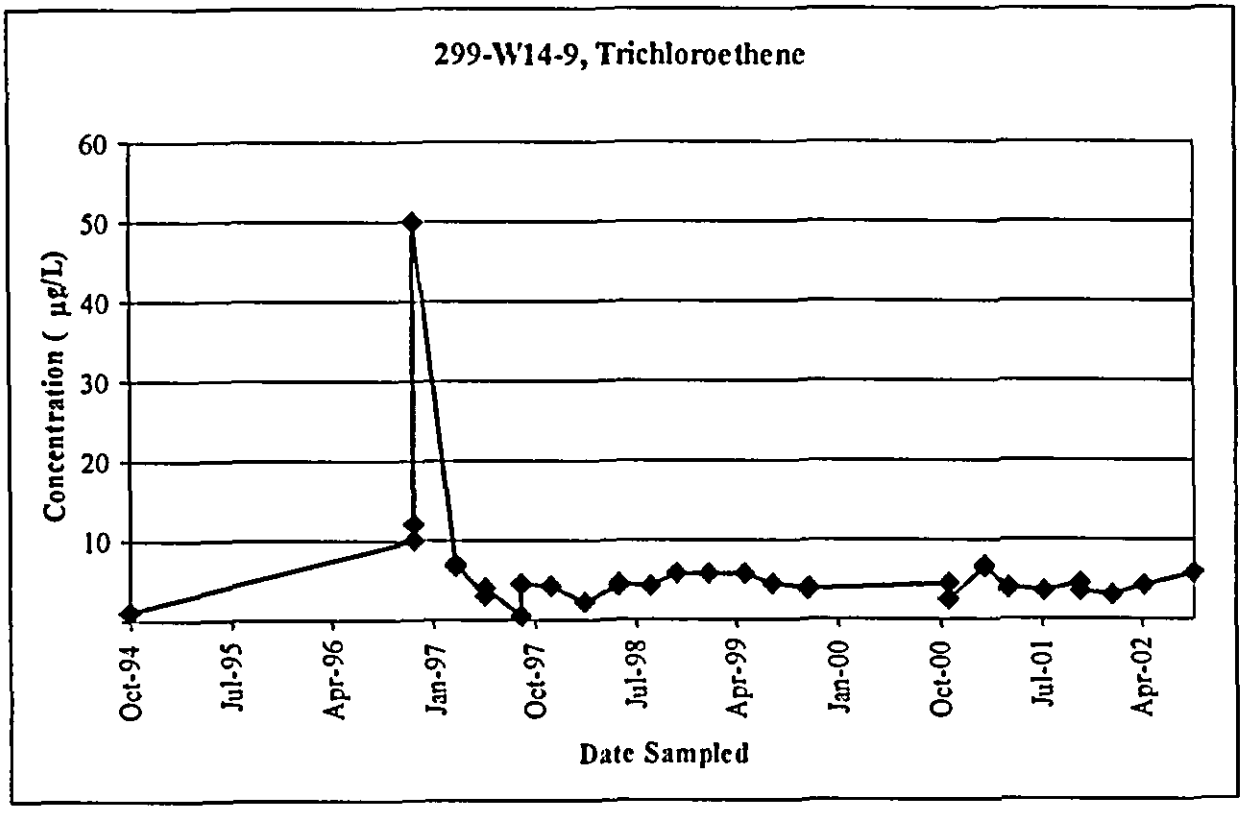
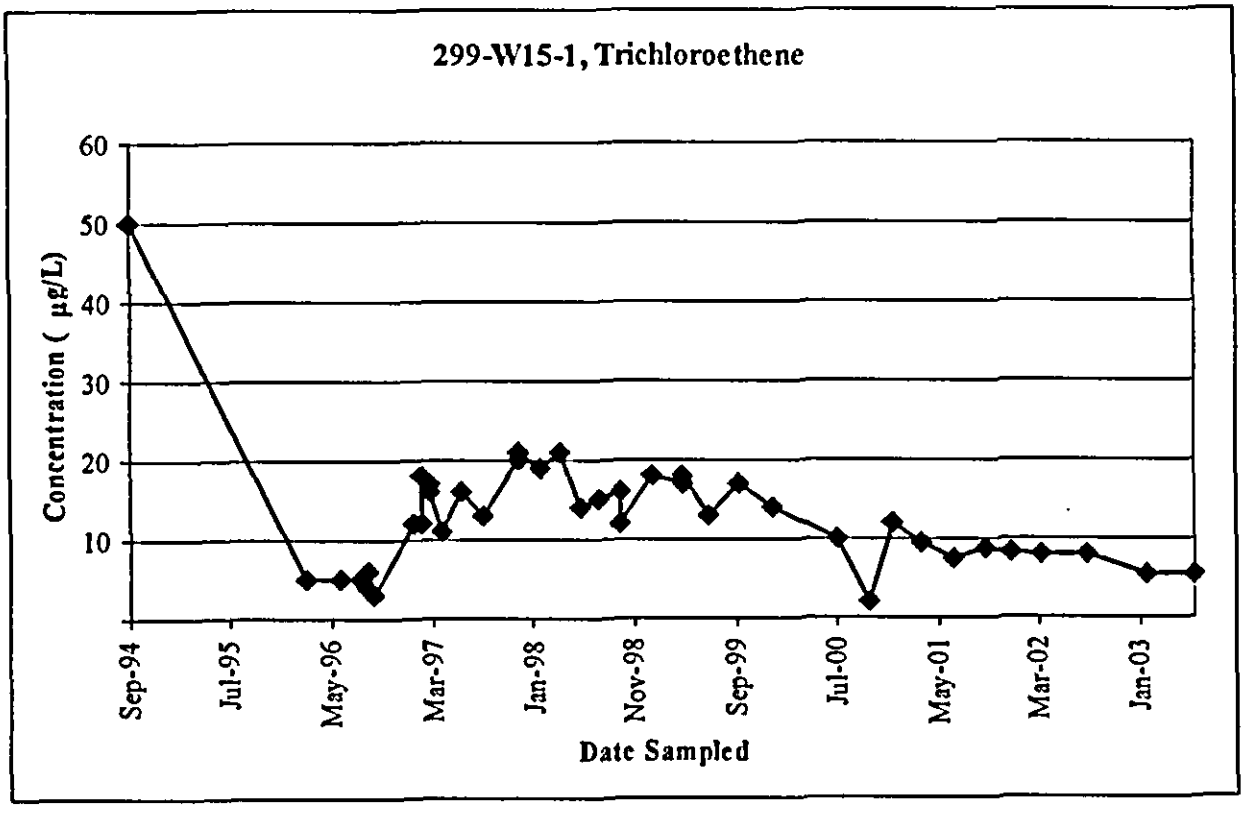


Figure H-3. 200-ZP-1 Groundwater Operable Unit, Trichloroethene Concentration Trends at Selected Monitoring Wells. (17 sheets)





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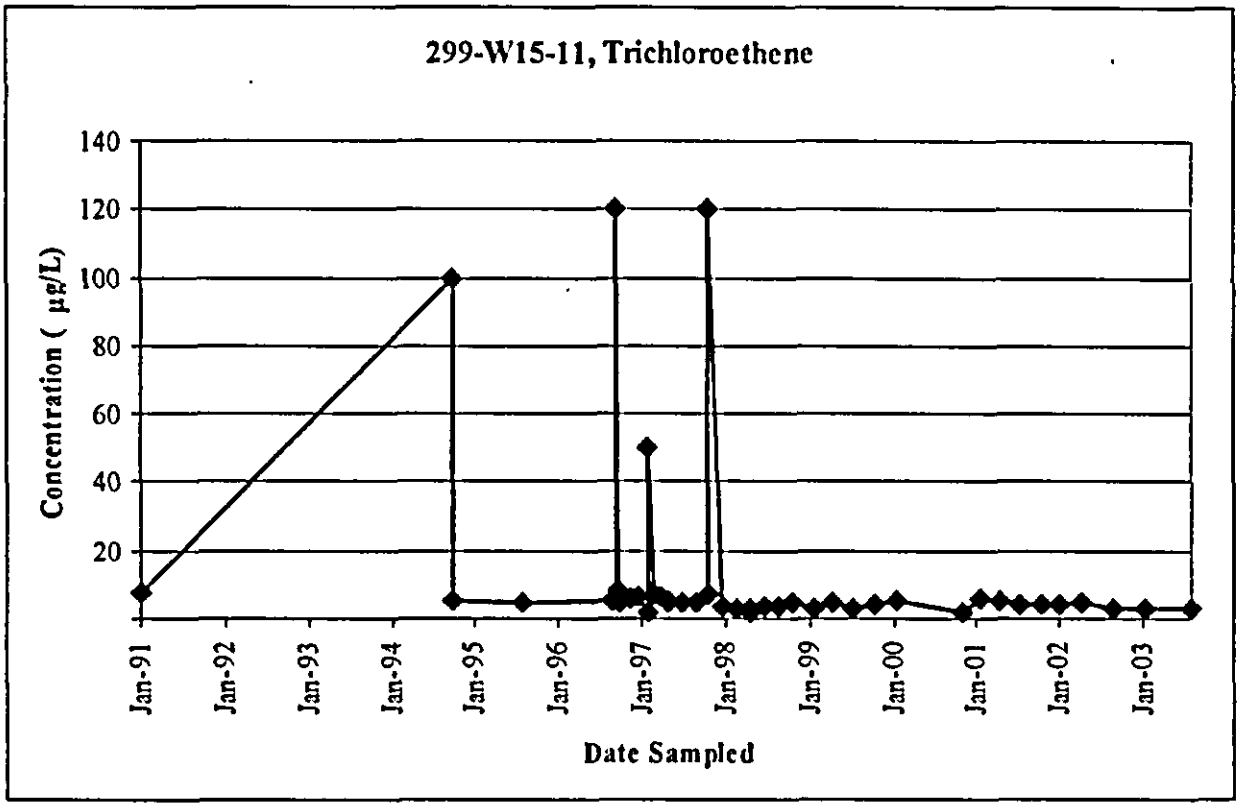


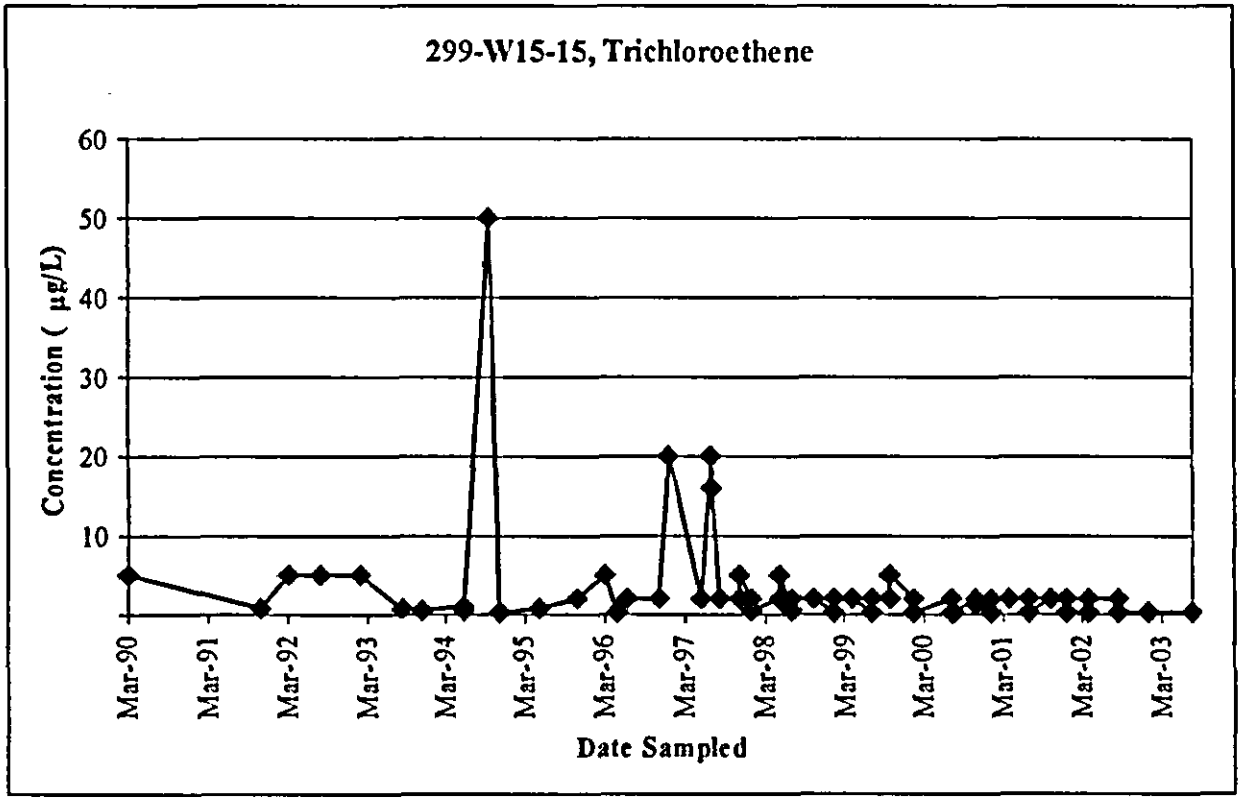
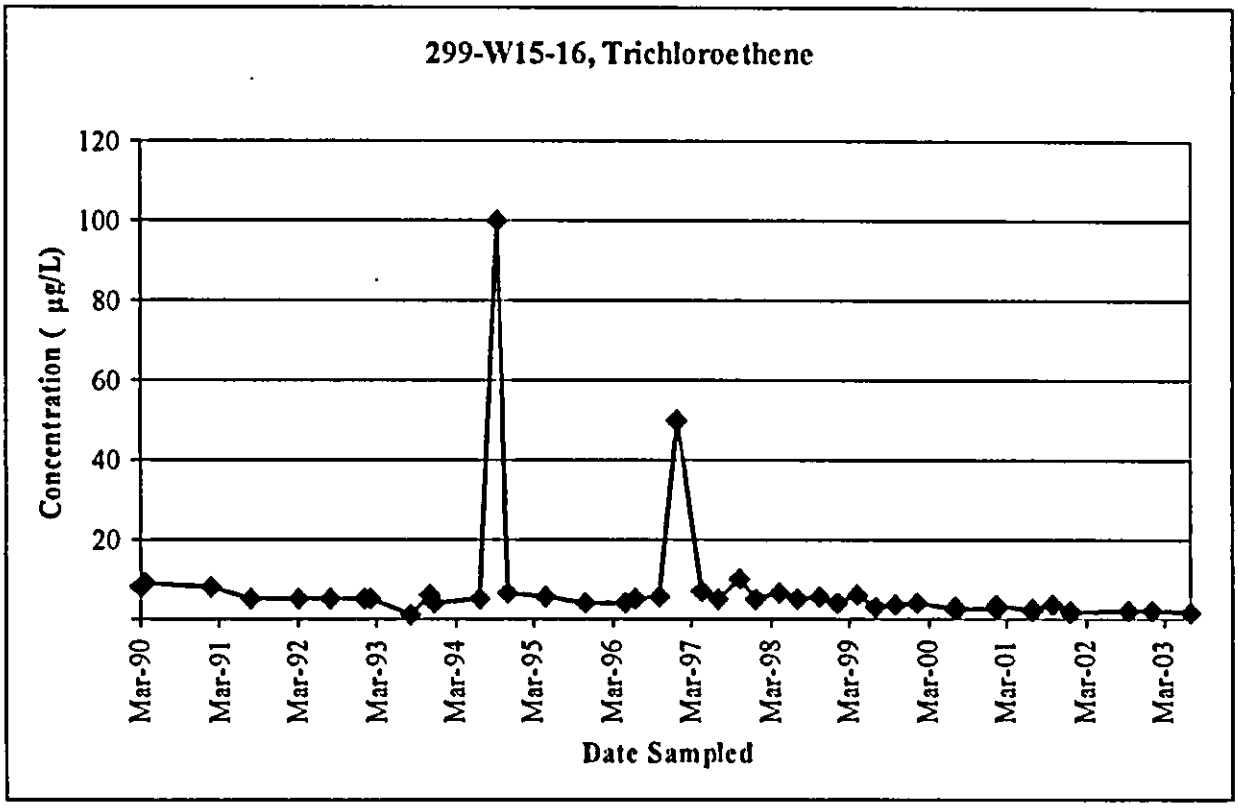
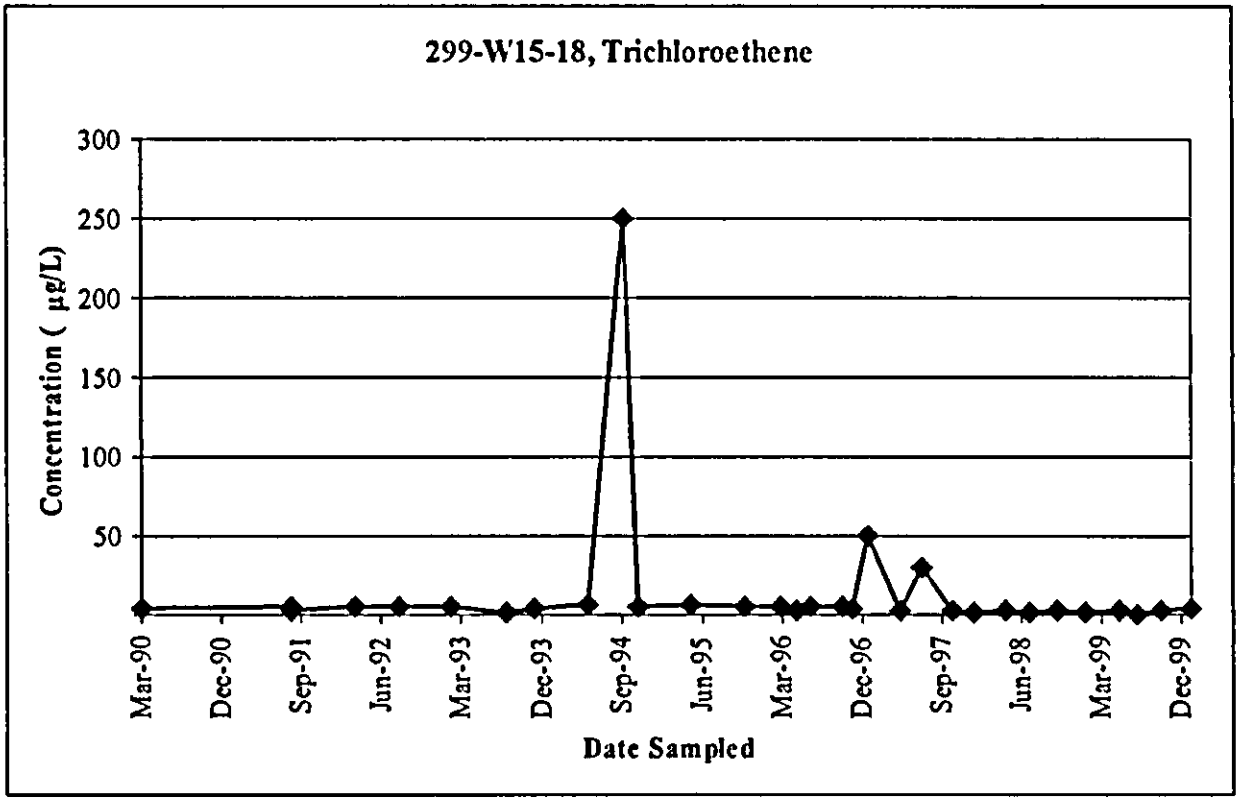


Figure H-3. 200-ZP-1 Groundwater Operable Unit, Trichloroethene Concentration Trends at Selected Monitoring Wells. (17 sheets)





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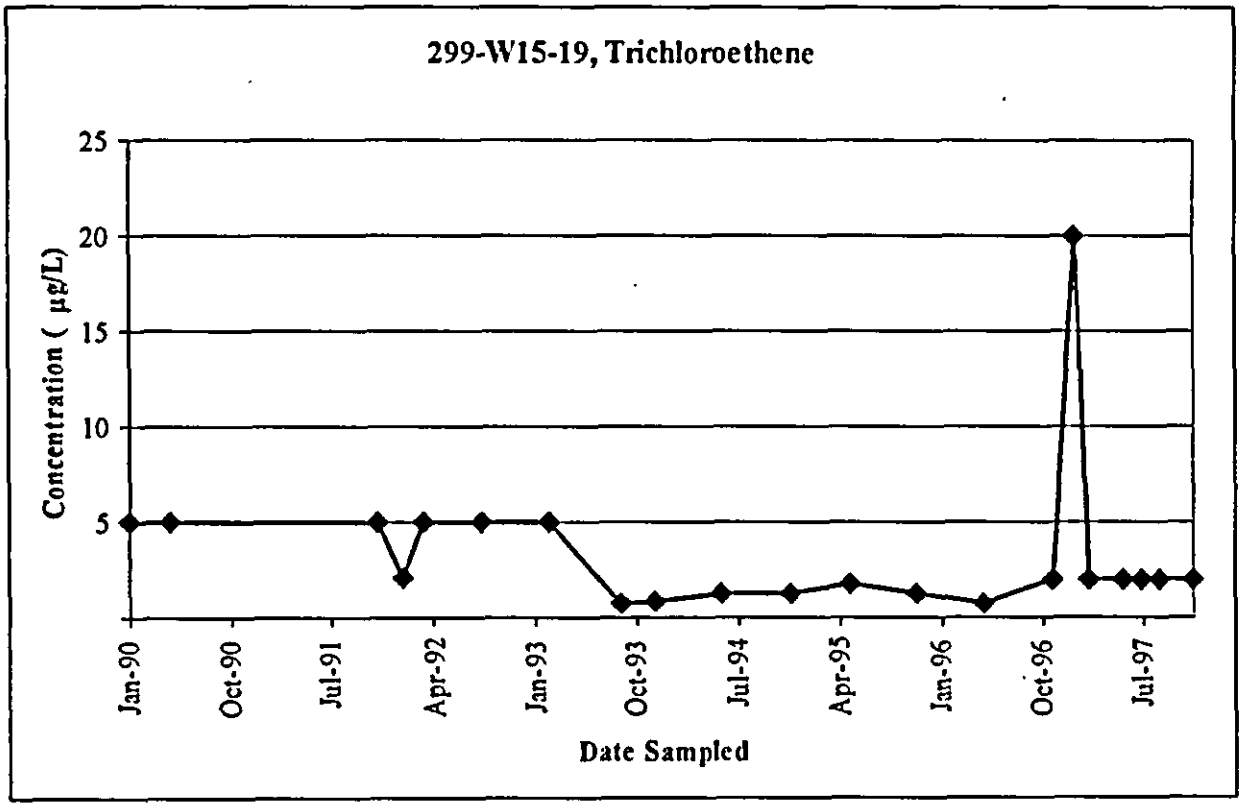

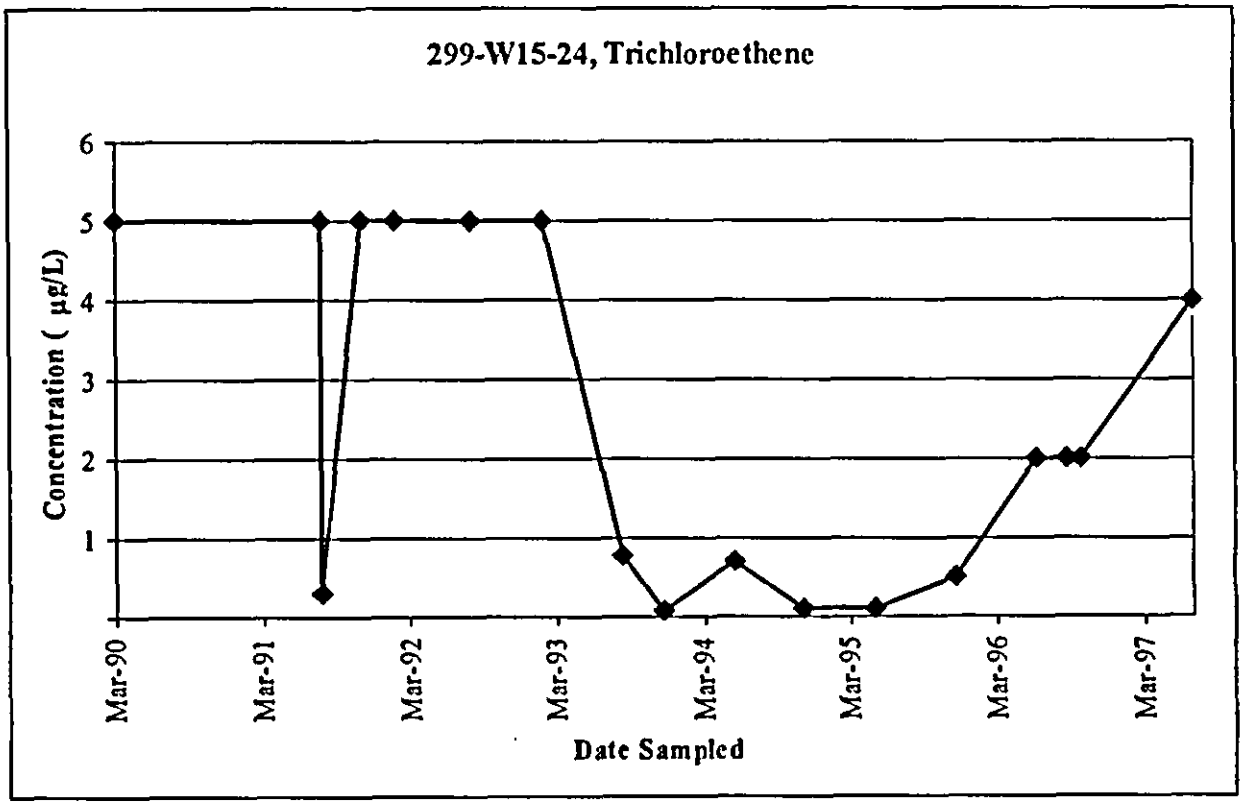

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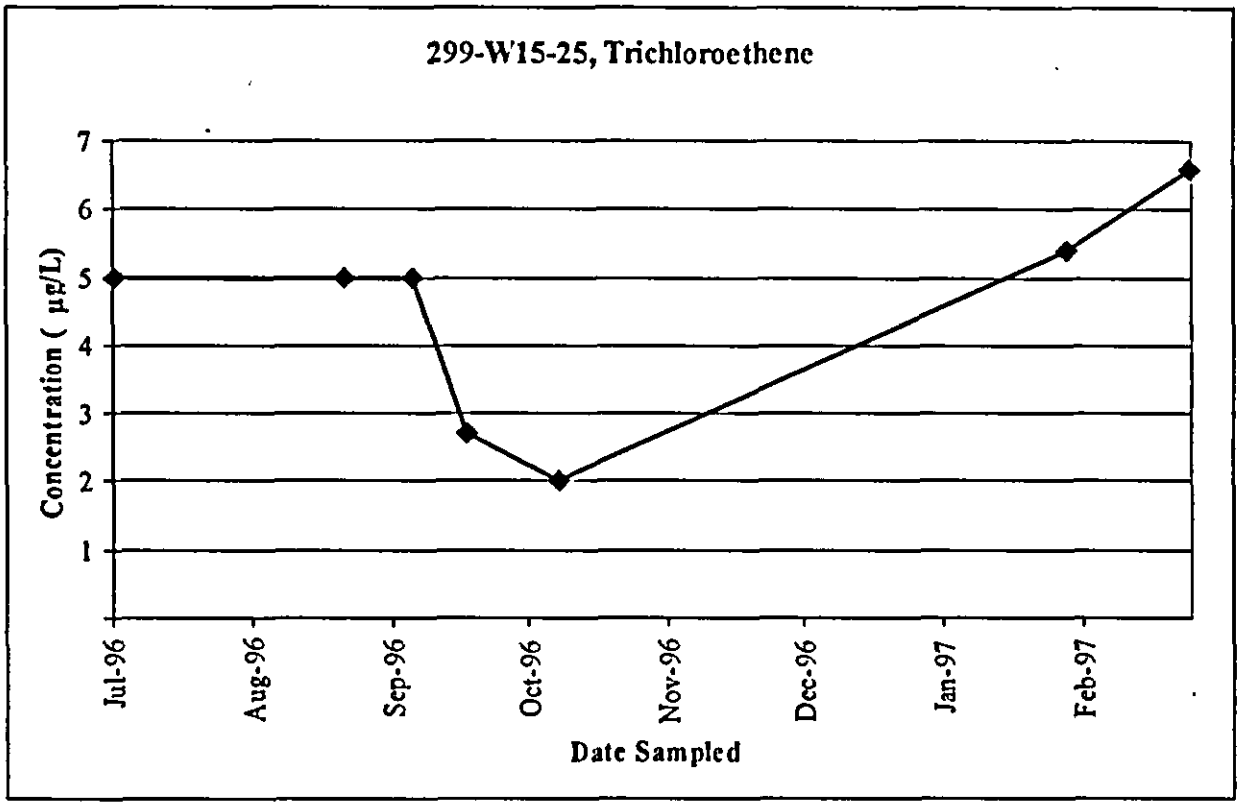

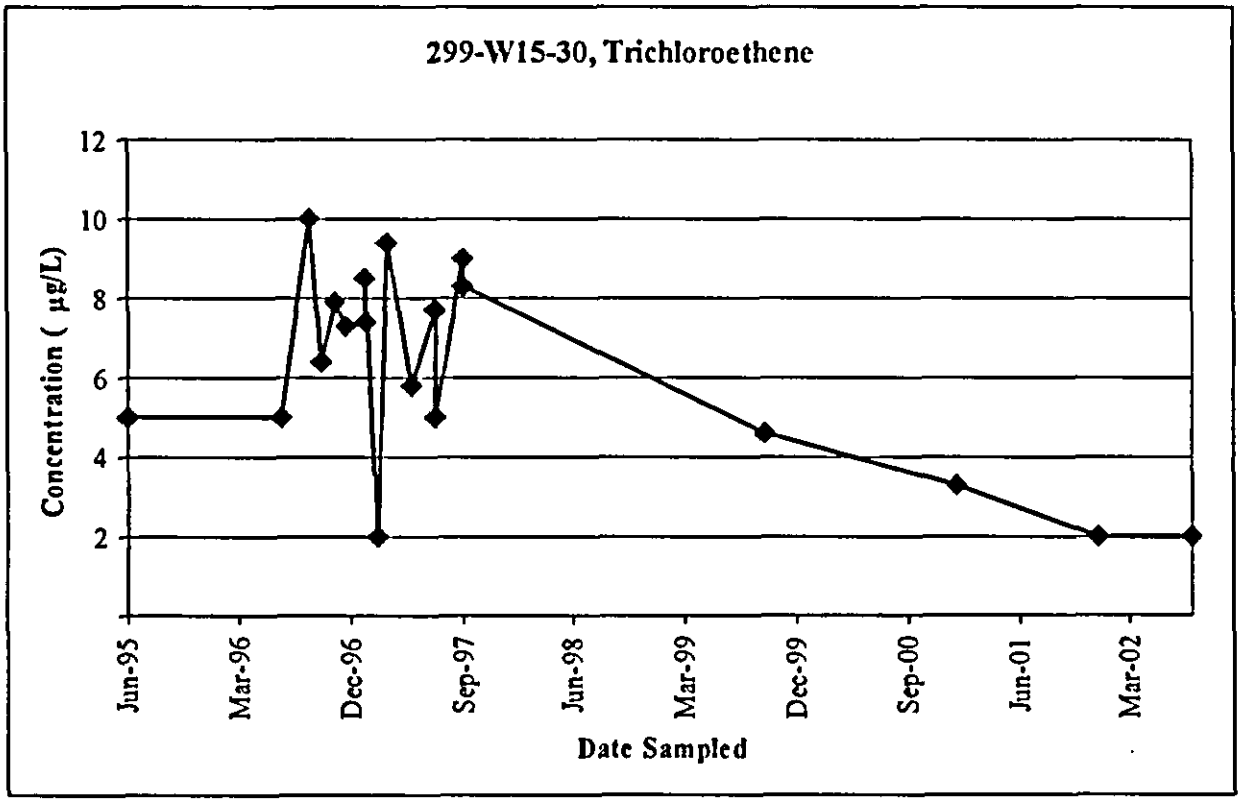

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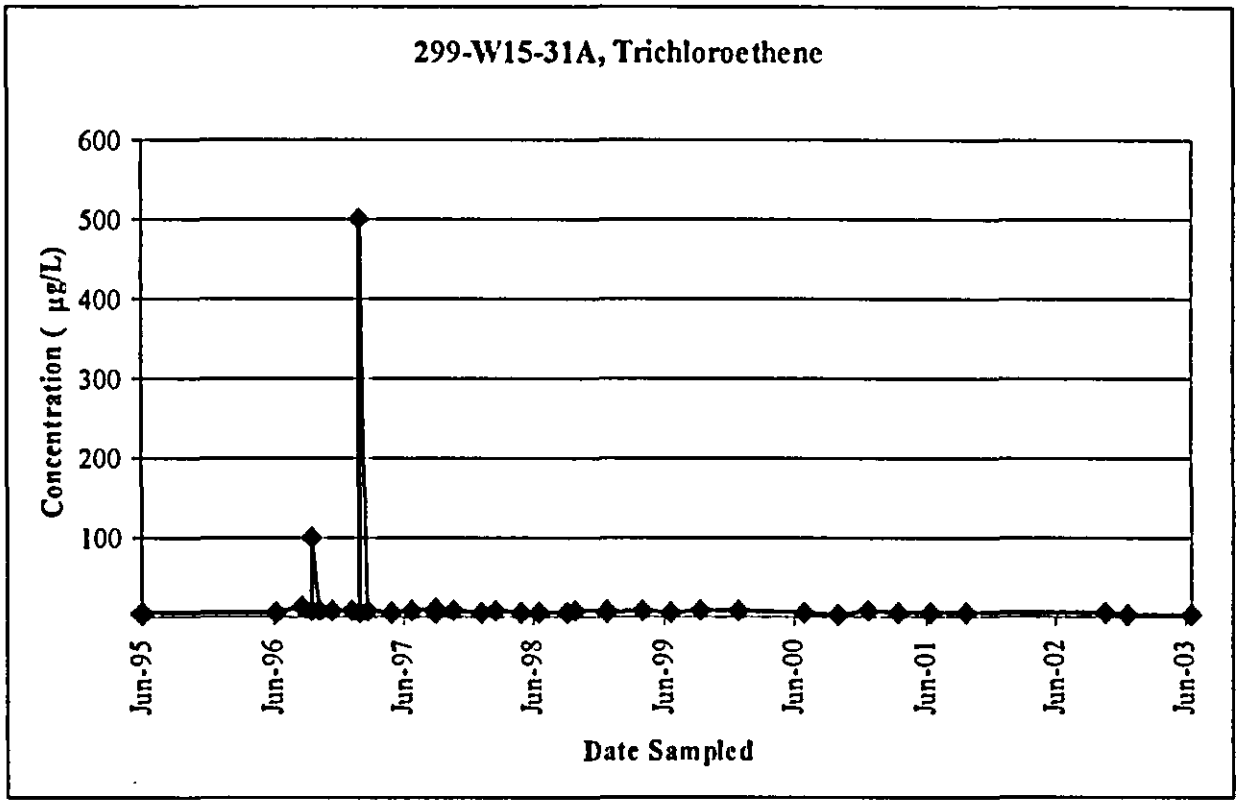

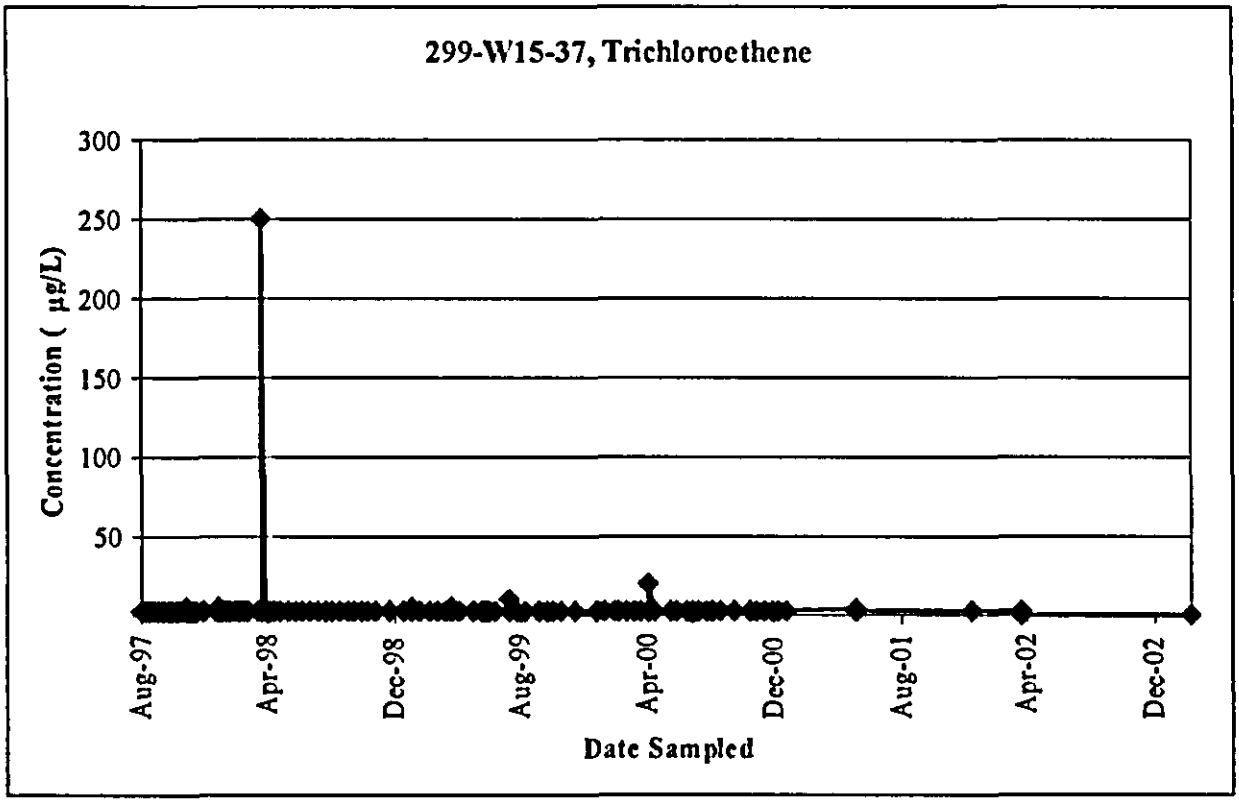

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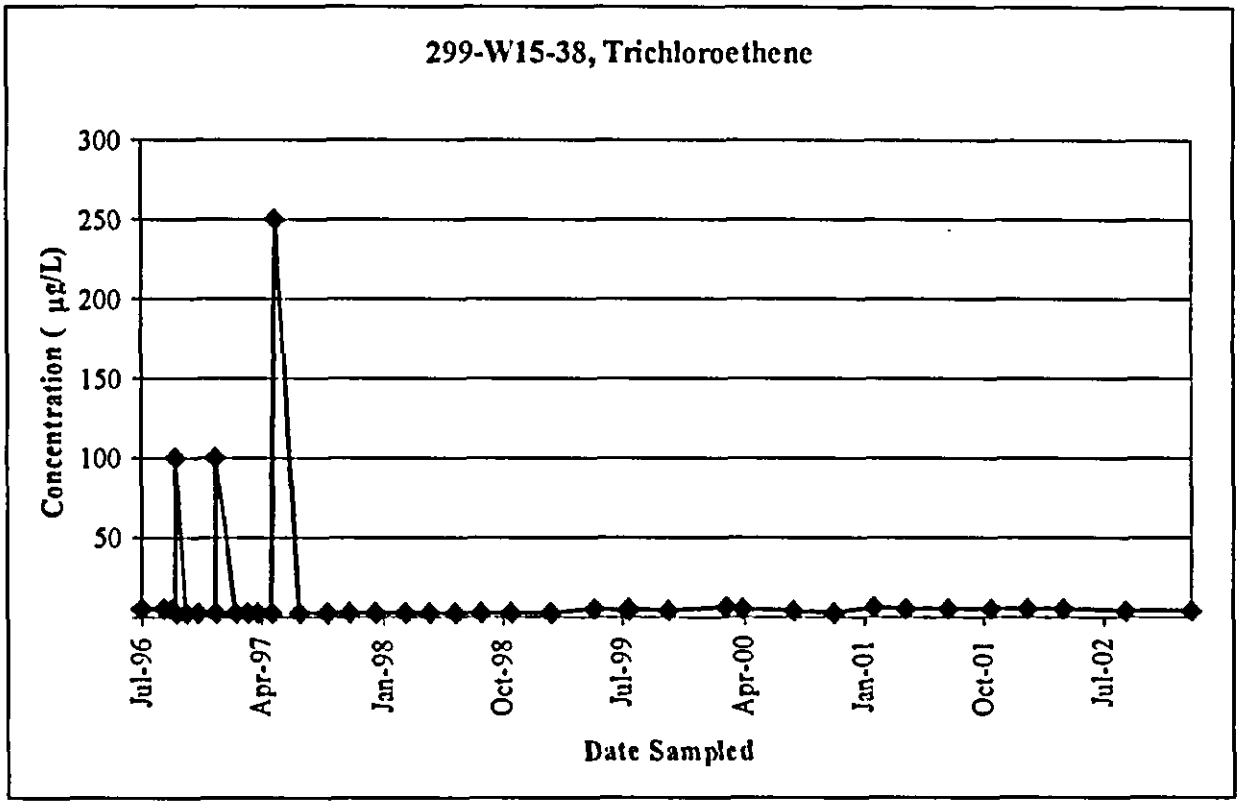

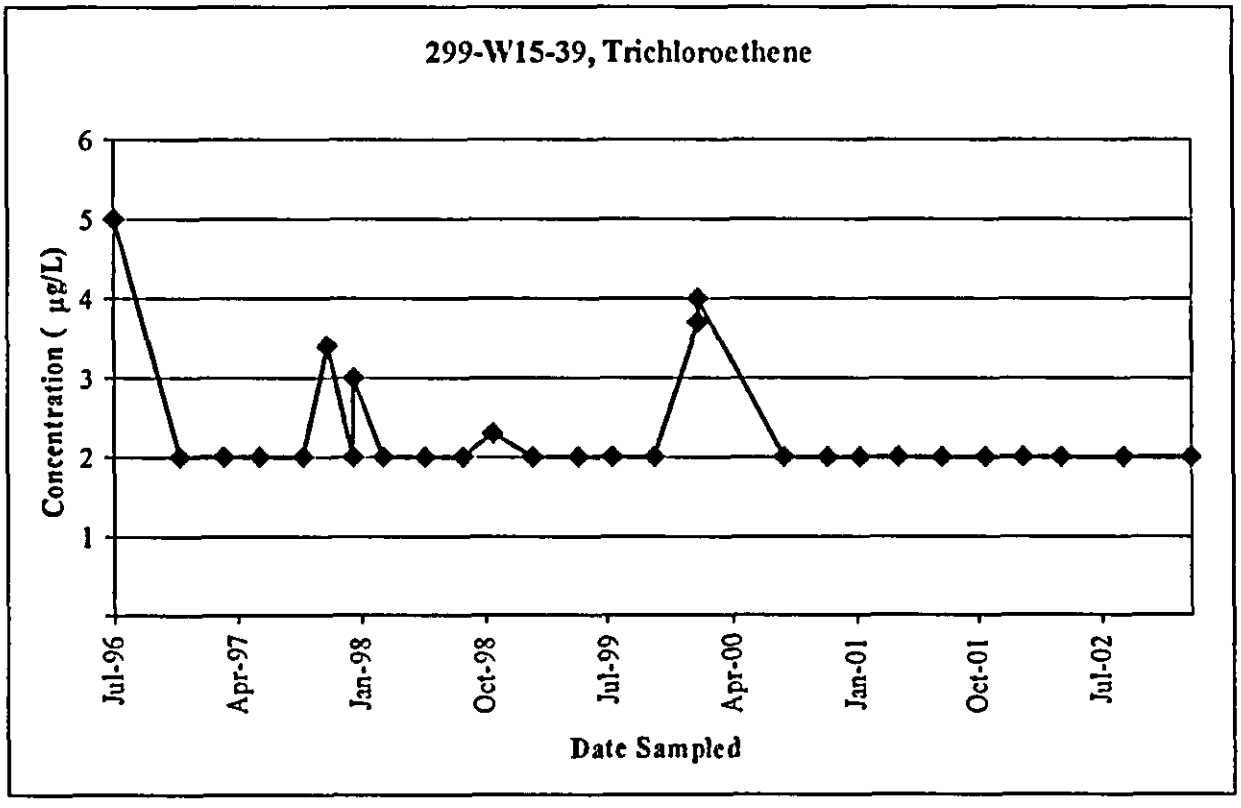

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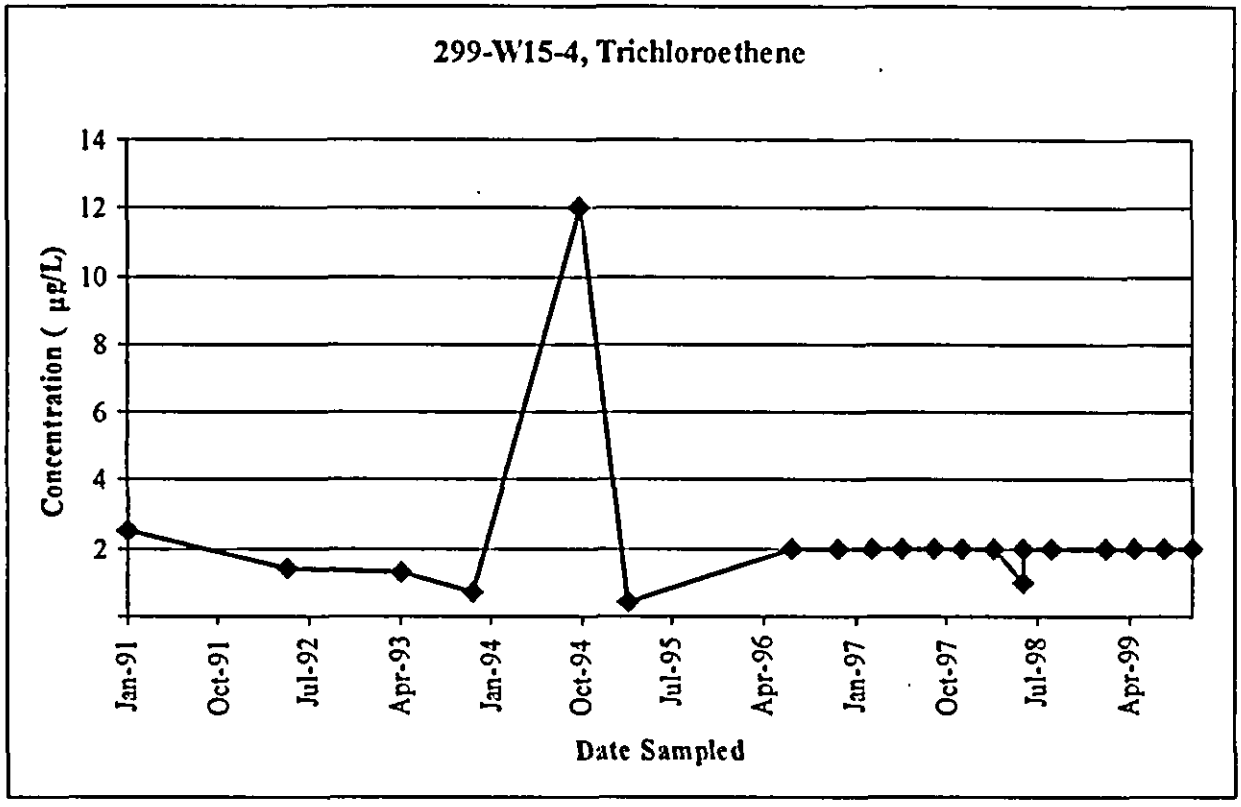

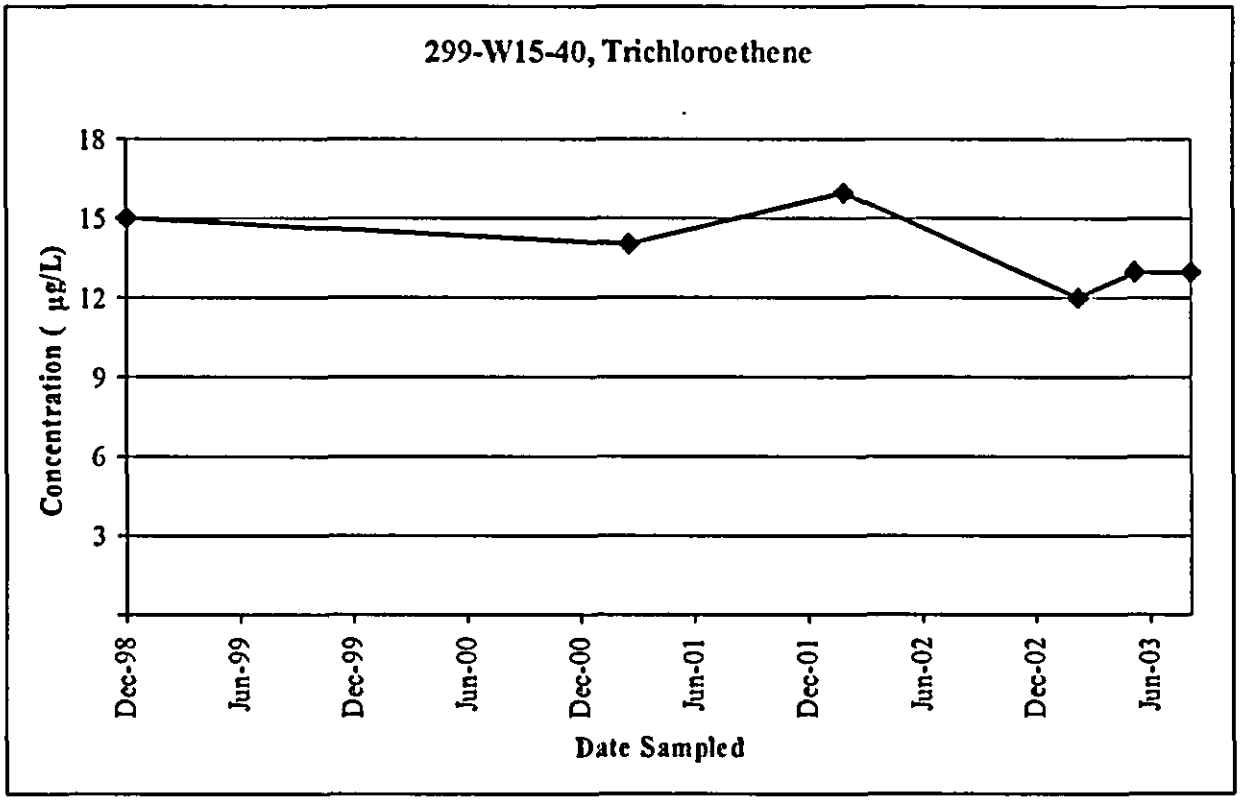

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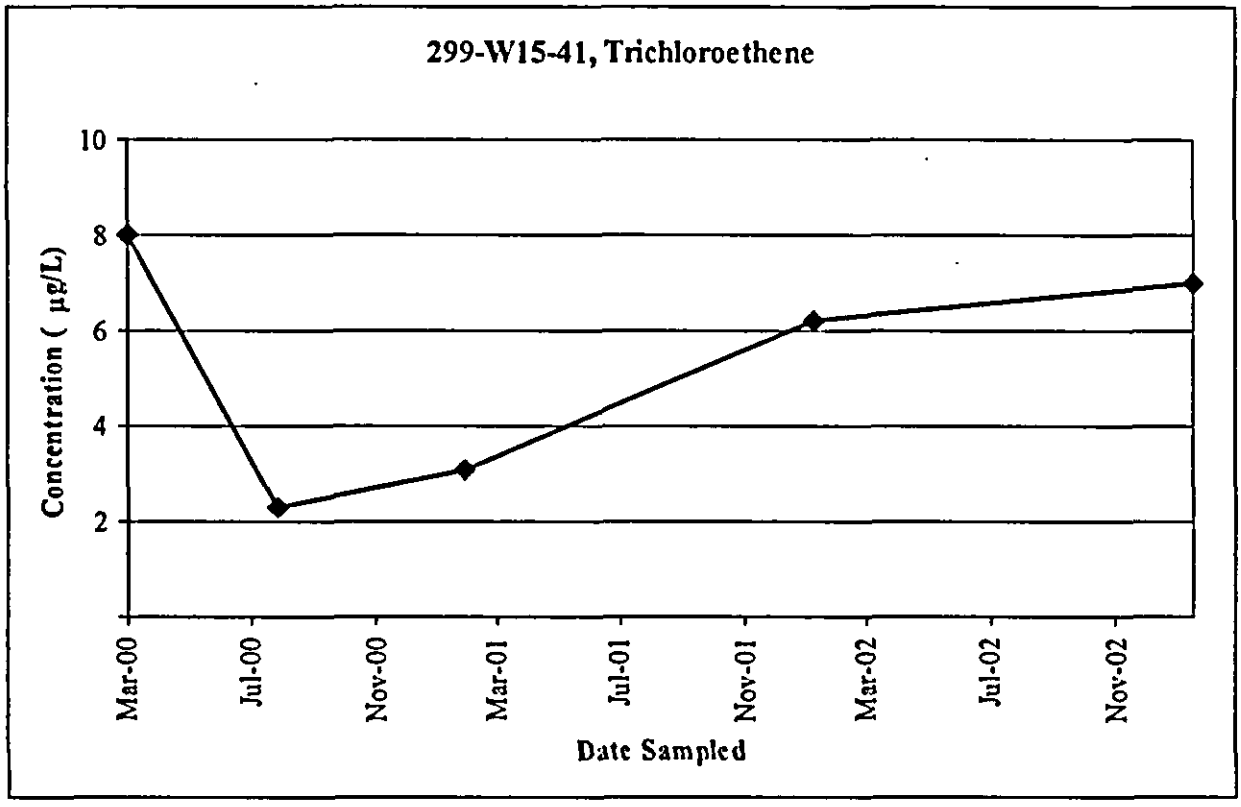

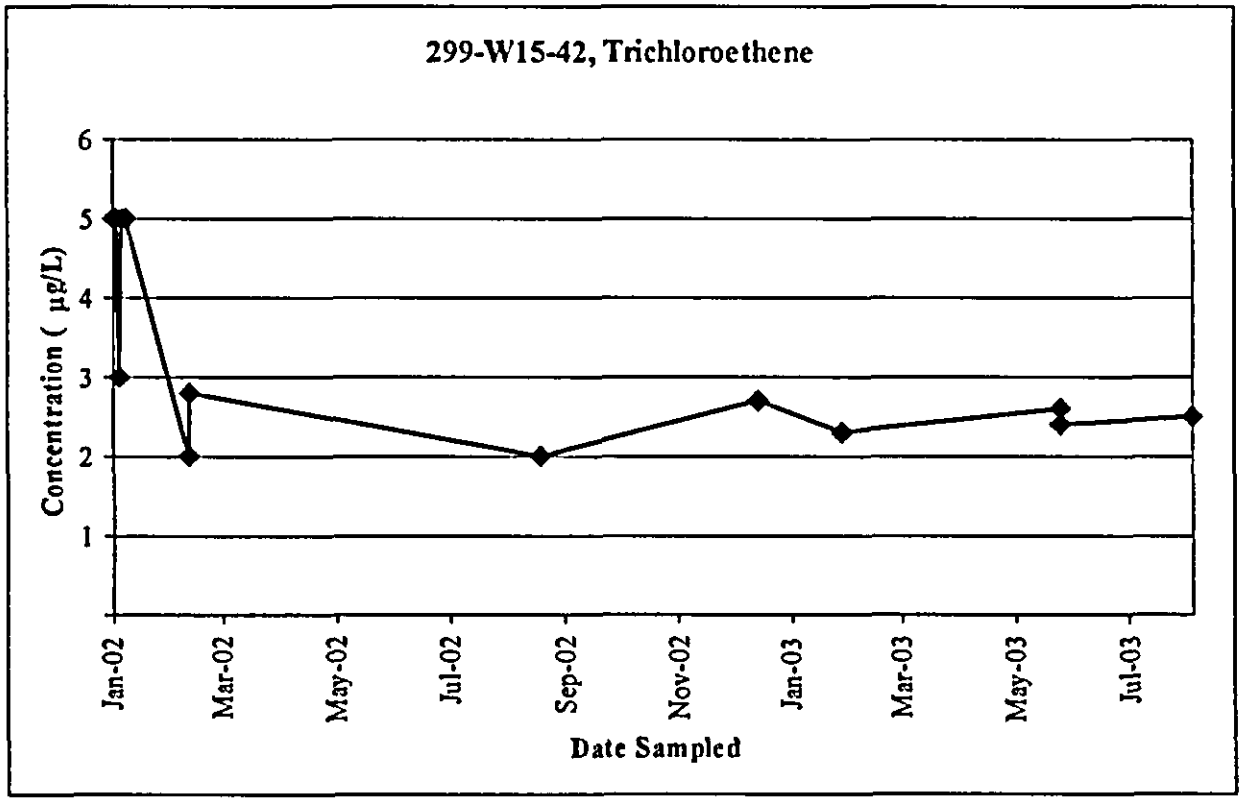

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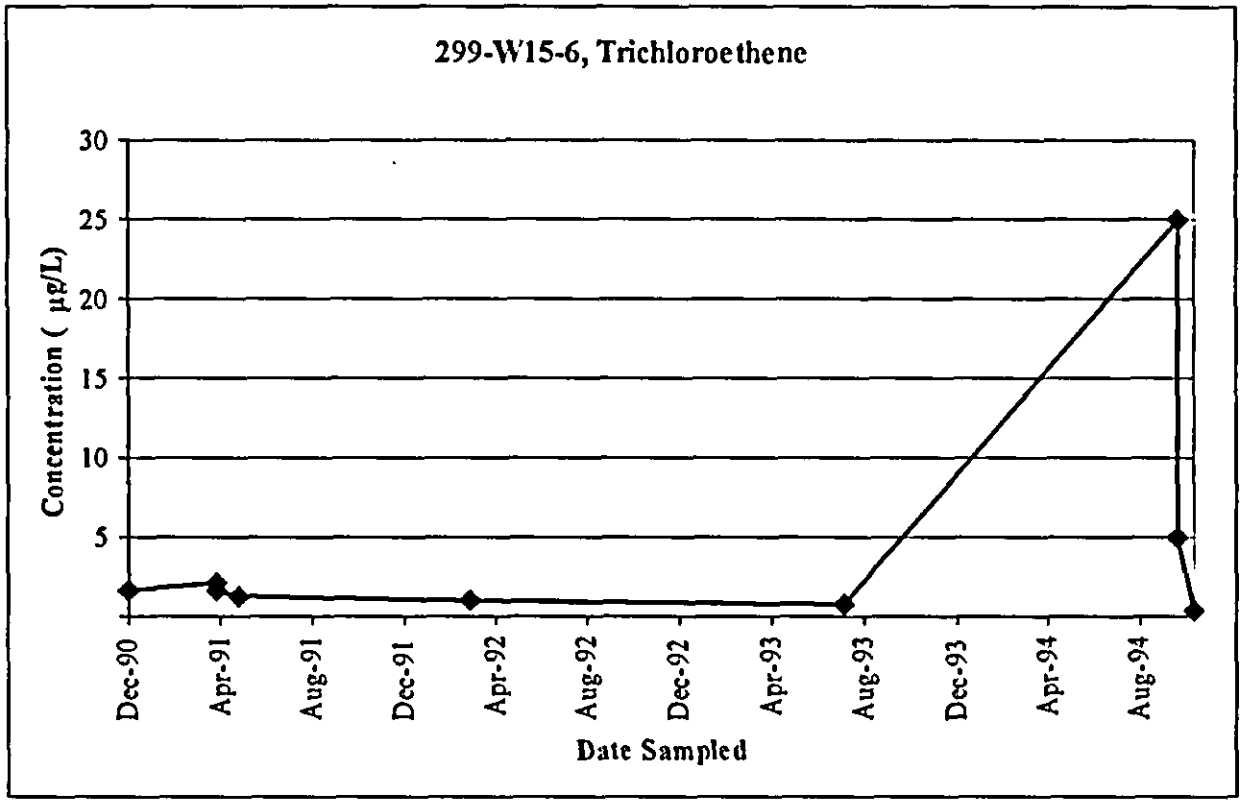

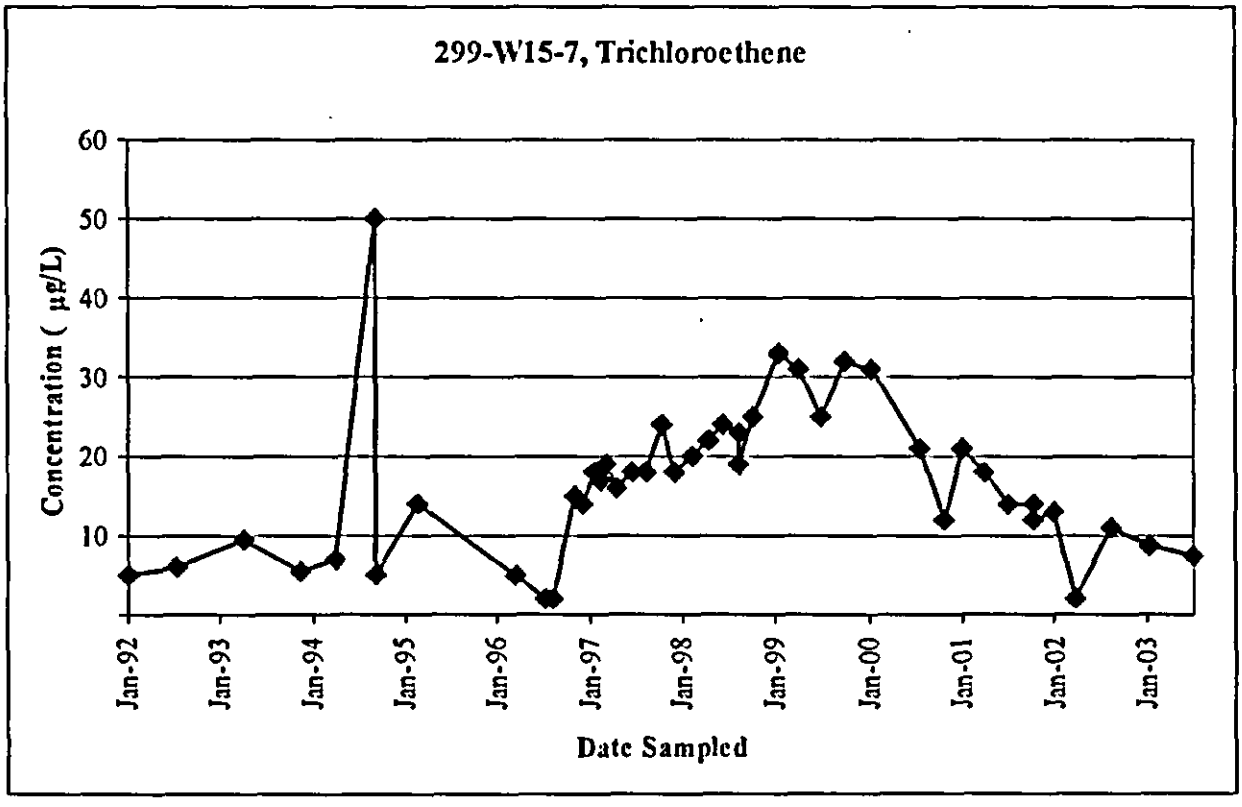

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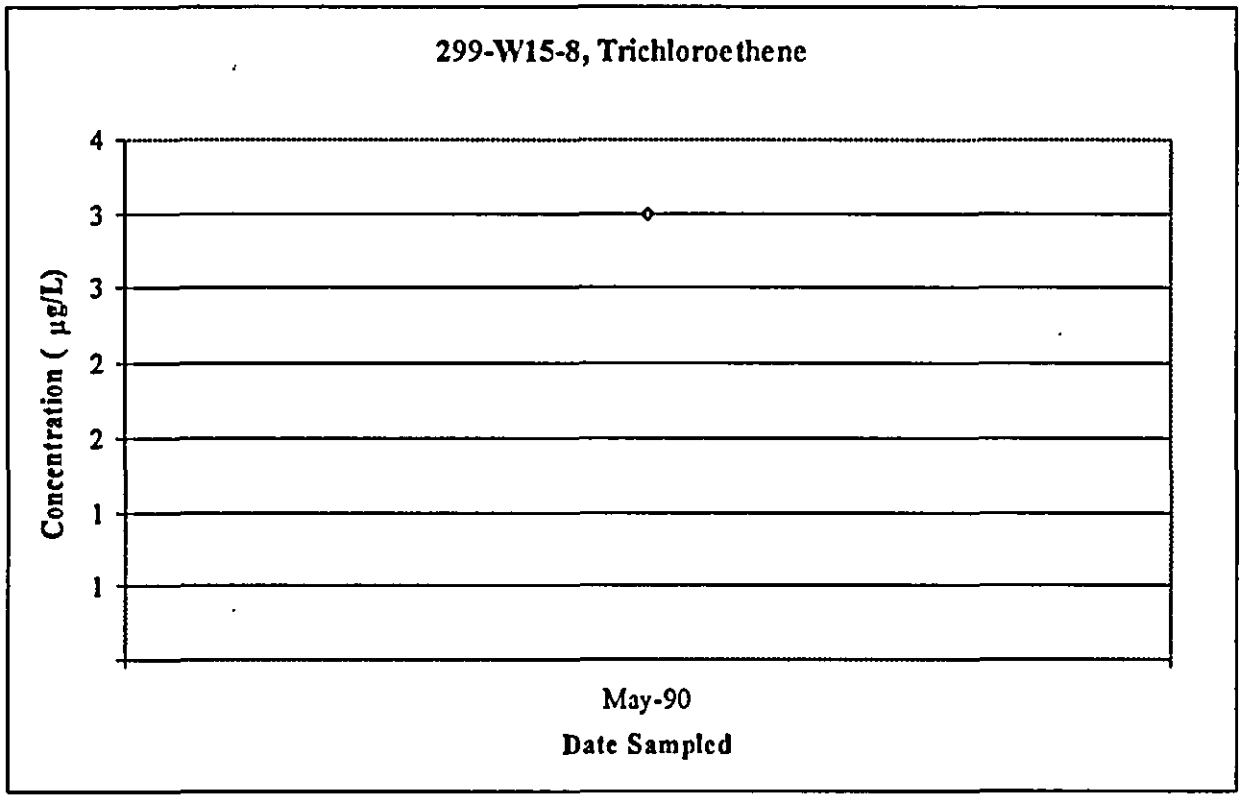

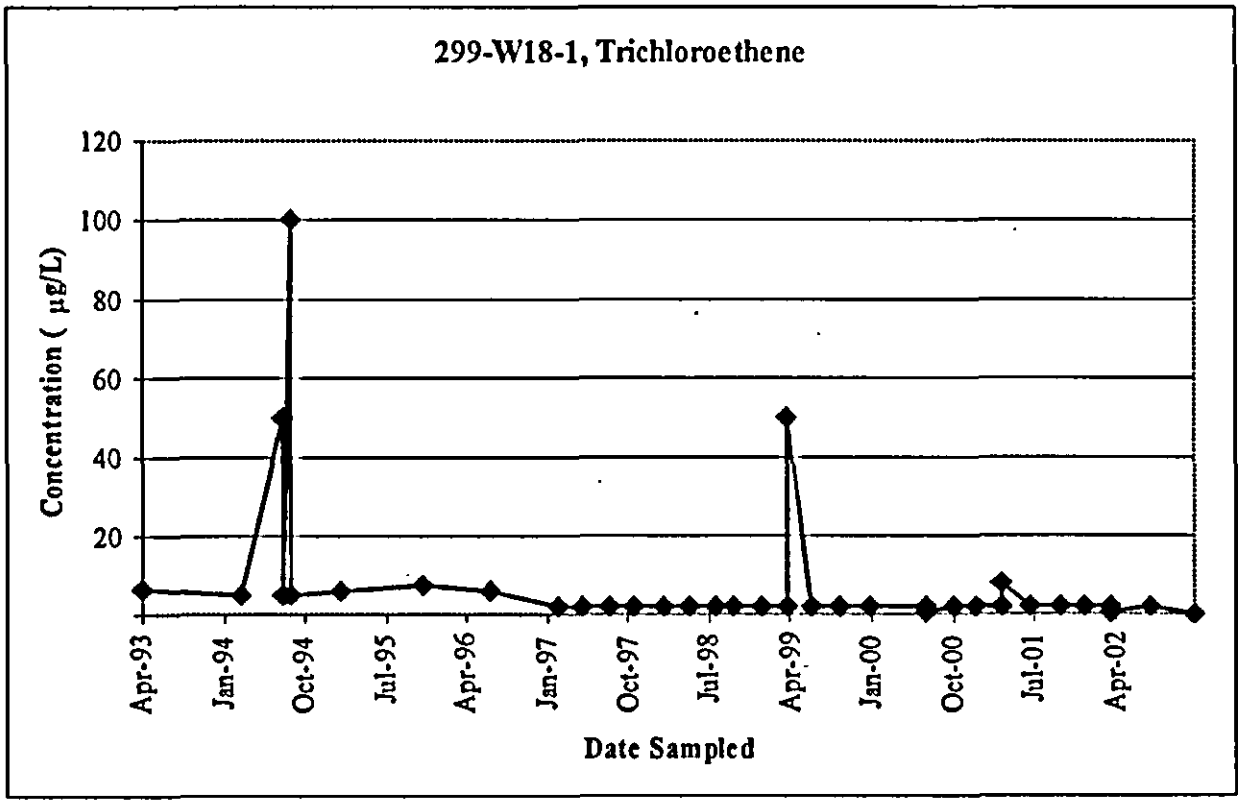

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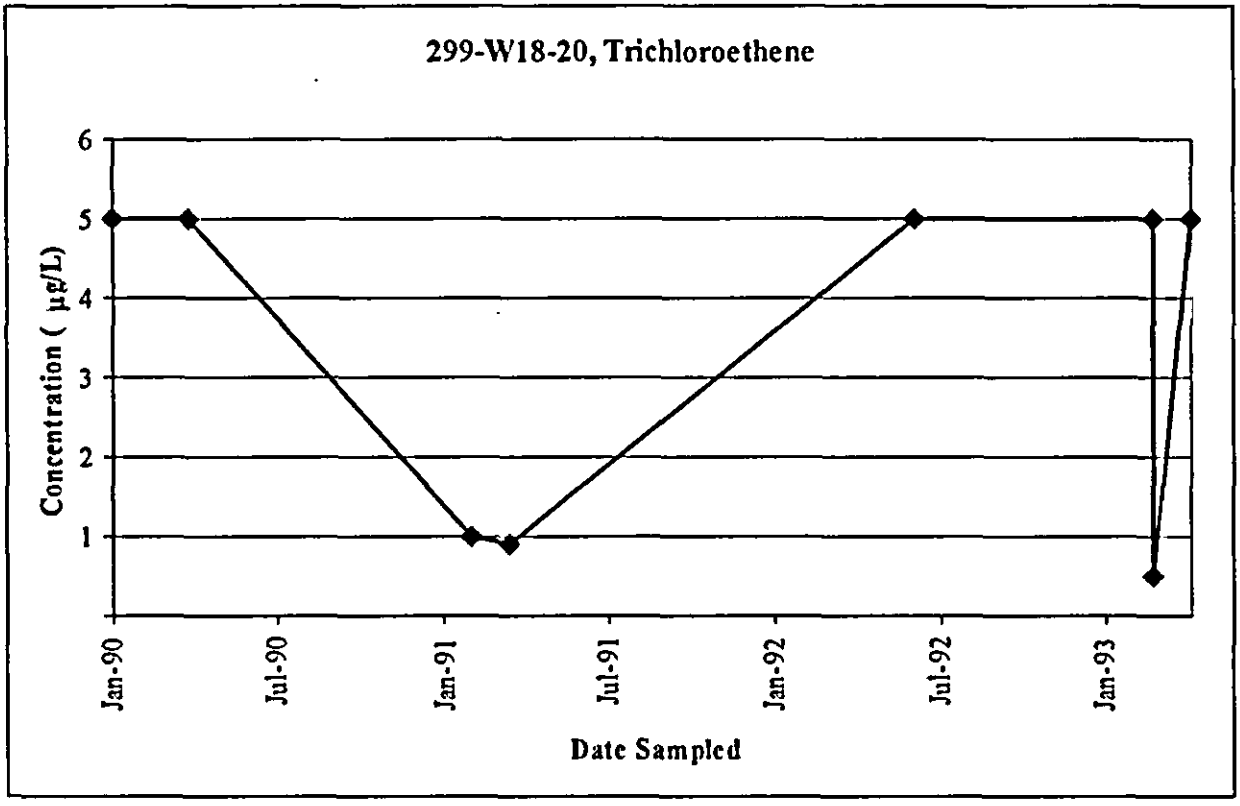

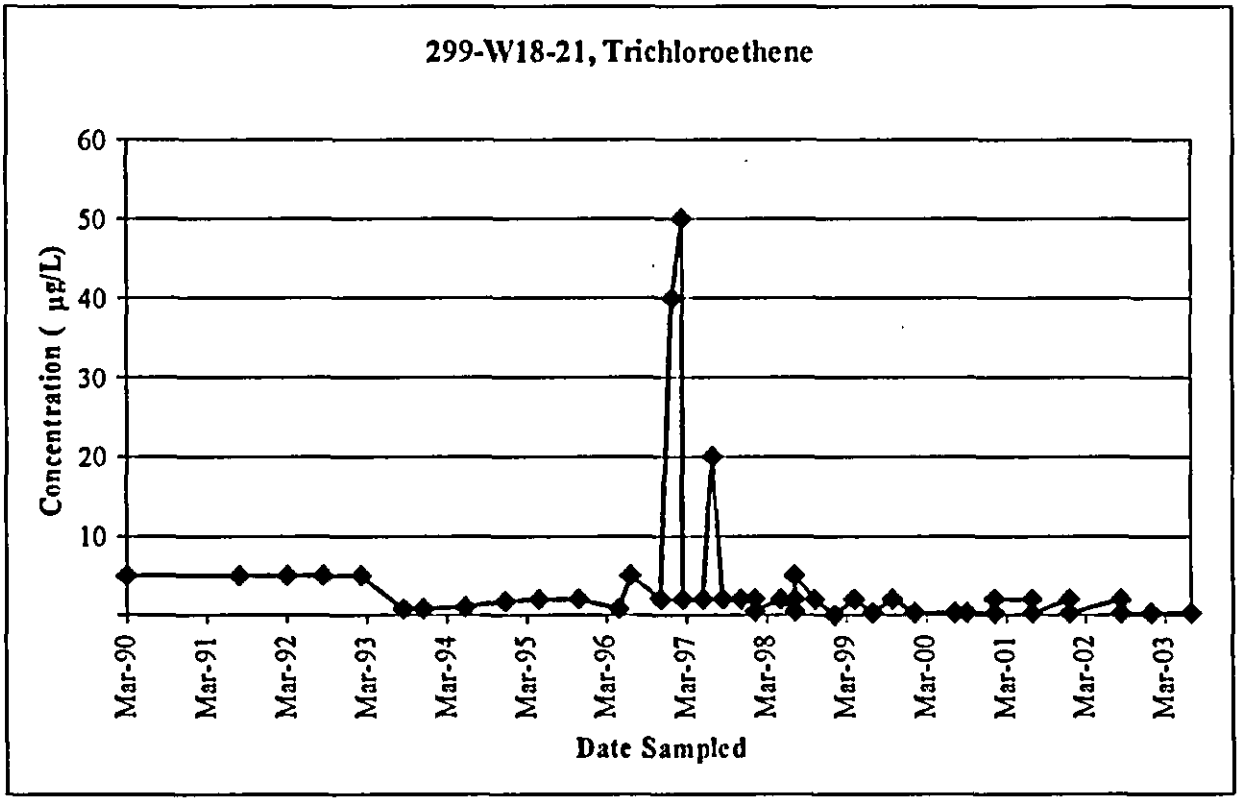

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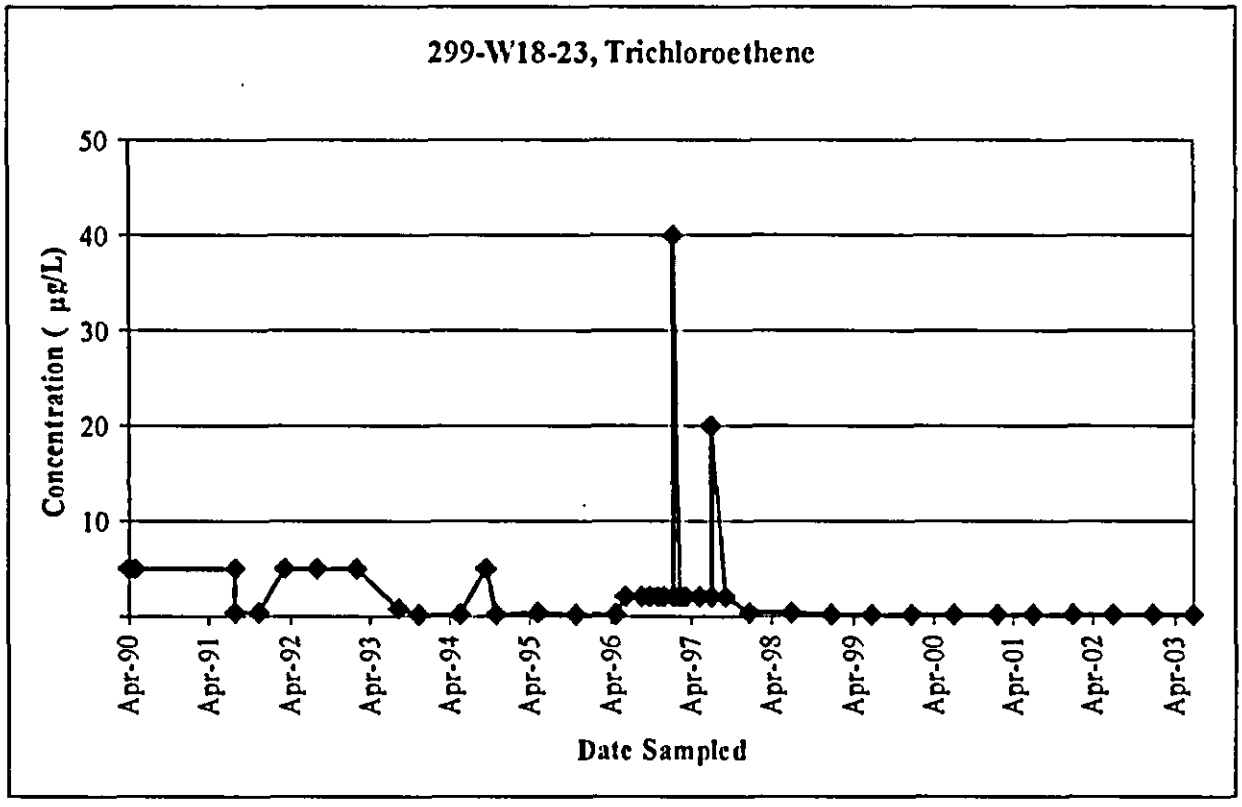

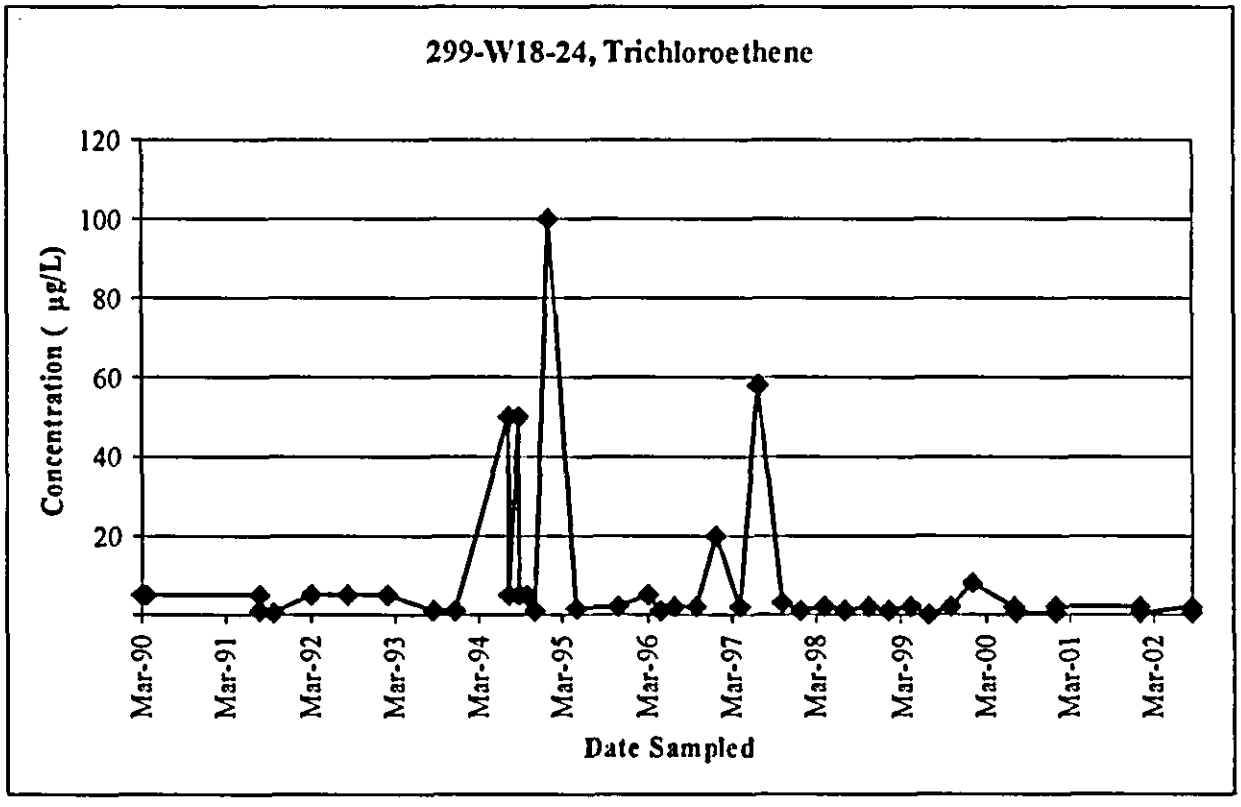

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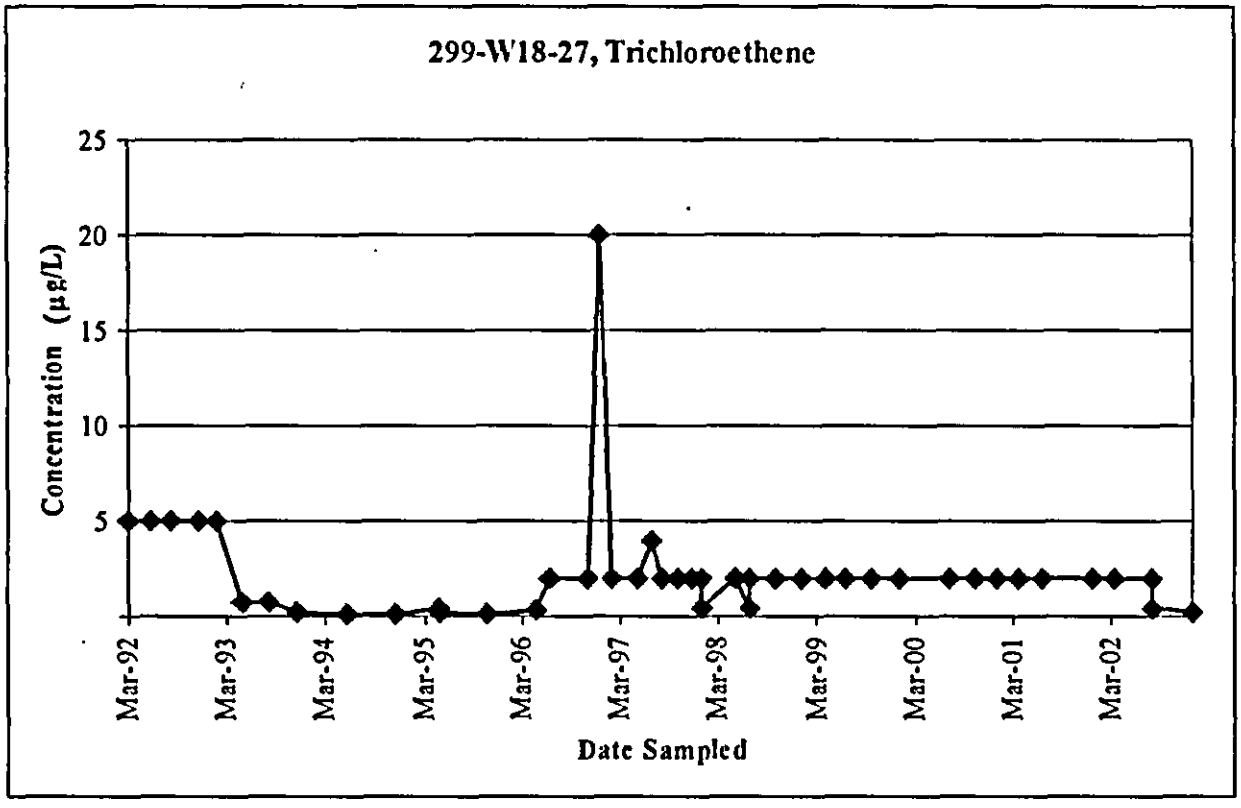

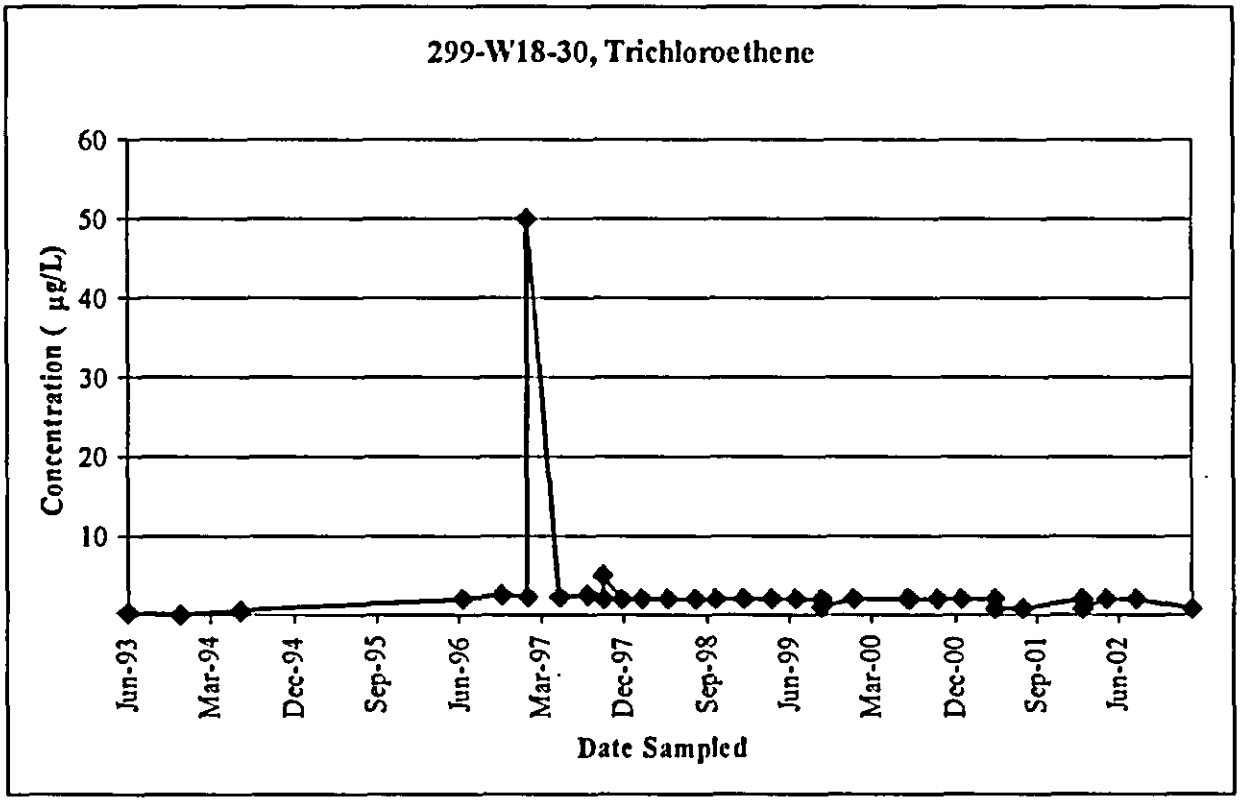

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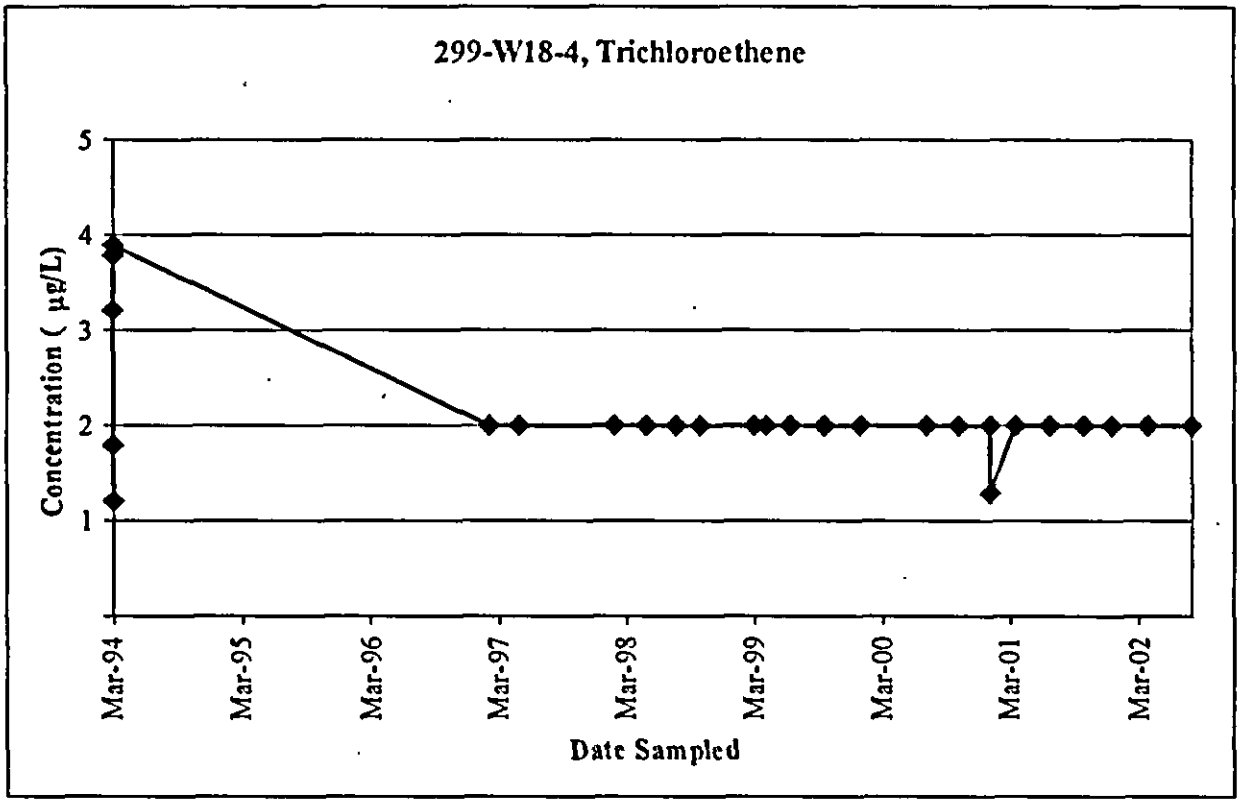

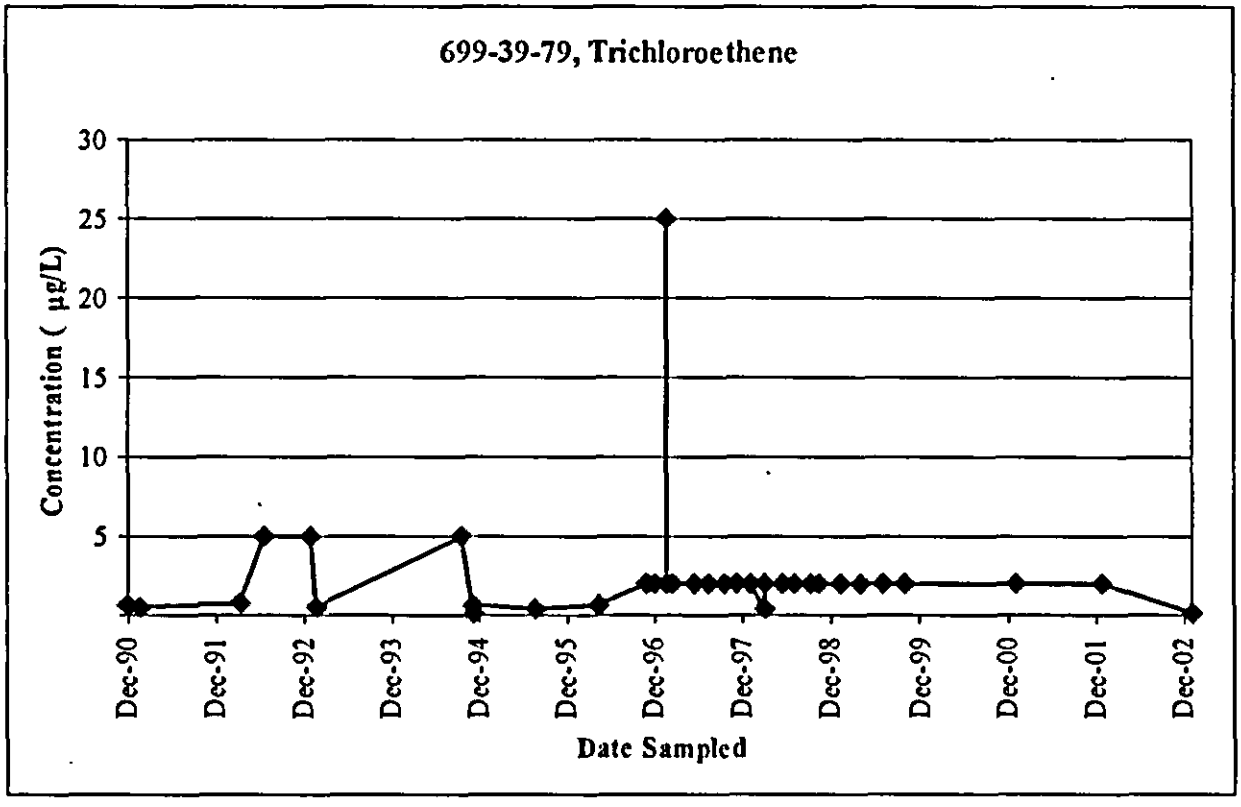

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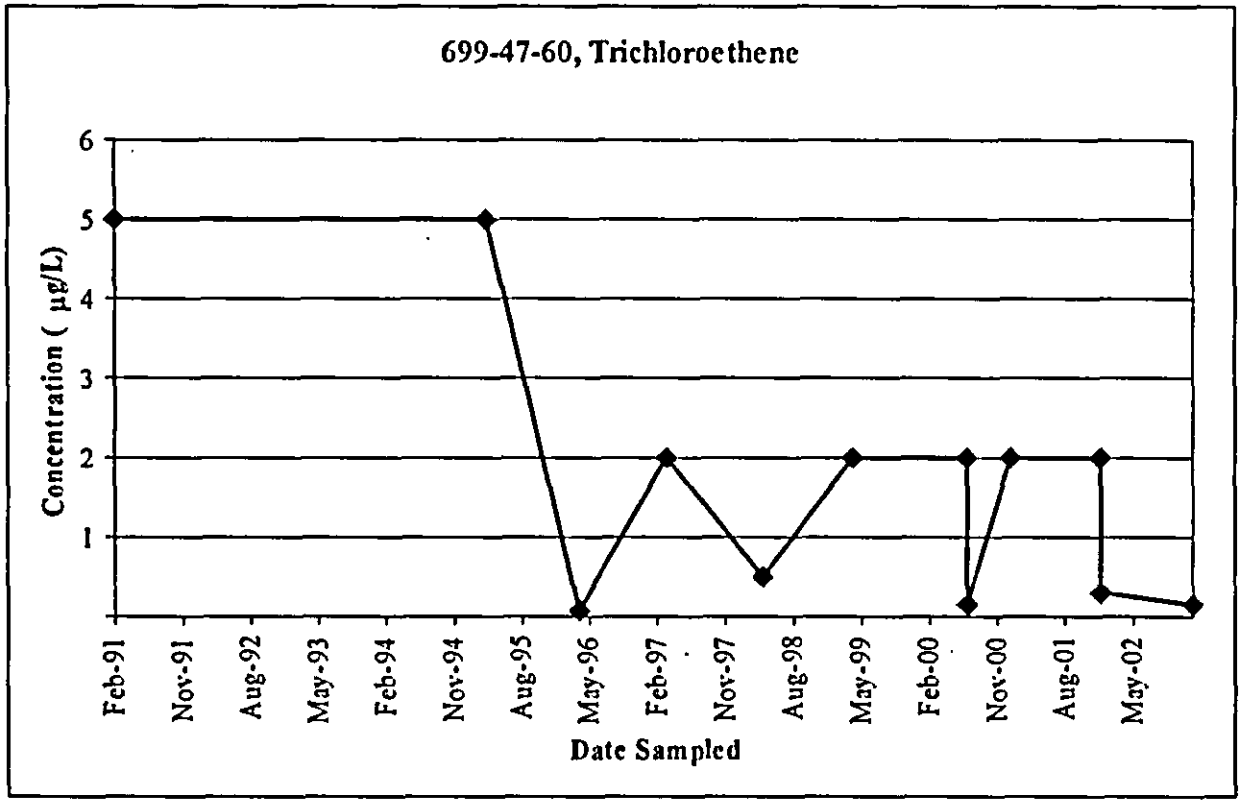

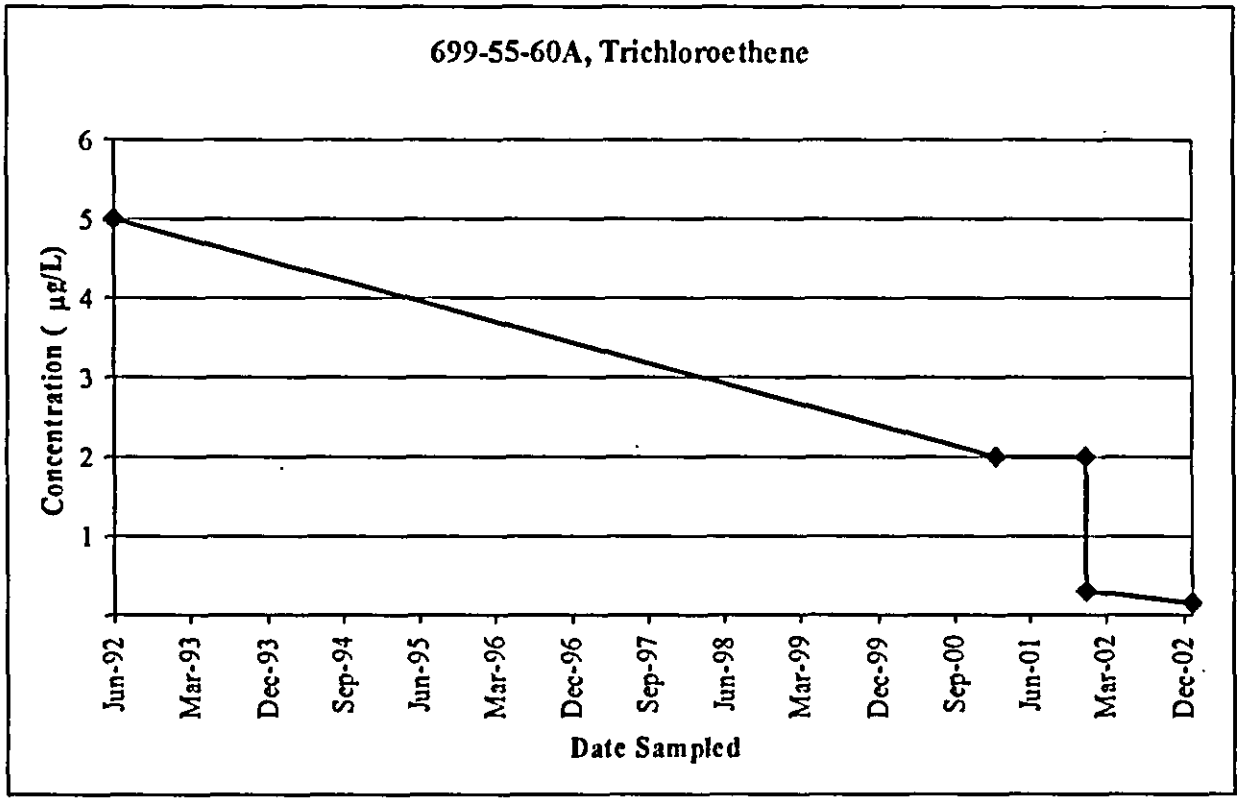

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